Run IIb CDF Detector Project

Project Management Plan

10 December 2002

Submitted, Approved and Accepted By:

CDF Run IIb Project Manager

P. Lukens

CDF Collaboration Spokespersons

A. Goshaw

N. Lockyer

Concurrence

Fermilab

J. Cooper
Head of Particle Physics Division

H. Montgomery
Associate Director for Research

M. Witherell
Director

Approval

Department of Energy

P. Philp
DOE Run II Project Manager

1. INTRODUCTION **5**
1.1 OVERVIEW OF THE PROJECT MANAGEMENT PLAN (PMP) 5
1.2 CDF RUN IIB DETECTOR PROJECT DESCRIPTION 5
1.3 HISTORICAL BACKGROUND 5
1.4 REFERENCE DOCUMENTS 6
2. JUSTIFICATION OF MISSION **7**
2.1 PHYSICS OBJECTIVES 7
2.2 TECHNICAL OBJECTIVES 7
2.3 COST OBJECTIVES FOR THE CDF RUN IIB DETECTOR PROJECT 8
2.4 SCHEDULE OBJECTIVES 8
3. PROJECT DESCRIPTION **9**
4. PROJECT MANAGEMENT, ORGANIZATION, AND RESPONSIBILITIES **11**
4.1 DEPARTMENT OF ENERGY 11
4.2 FERMILAB DIRECTOR AND DEPUTY DIRECTOR 12
4.3 FERMILAB ASSOCIATE DIRECTOR FOR RESEARCH 13
4.4 FERMILAB PARTICLE PHYSICS DIVISION HEAD 13
4.5 PROJECT MANAGER 14
4.6 PROJECT LEADERS 15
4.7 ADVISORY FUNCTIONS 16
4.7.1 Project Management Group *16*
4.7.2 Spokespersons *17*
4.7.3 CDF Executive Board *17*
4.7.4 Internal Review Committees *17*
4.7.5 Subproject Technical Committees *17*
4.7.6 Godparent Committees *18*
5. WORK BREAKDOWN STRUCTURE **19**
5.1 SVXIIB 19
5.2 CALORIMETER 20
5.2.1 Central Preradiator System *20*
5.2.2 EM Timing *21*
5.3 DATA ACQUISITION AND TRIGGER SYSTEMS 21
5.3.1 Event Builder *21*
5.3.2 Track Trigger Upgrade *22*
5.3.3 Replacement of the TDCs *22*
5.3.4 Replacement of the Level 2 Decision Crate *22*
5.3.5 Replacement of the Level 3 Processors *22*
5.4 PROJECT ADMINISTRATION 23
6. RESOURCE PLAN **24**
6.1 EQUIPMENT RESOURCES 24
6.2 PERSONNEL RESOURCES 24
7. TECHNICAL, SCHEDULE, AND COST **25**
8. CHANGE CONTROL THRESHOLDS **26**

9. RISK MANAGEMENT ASSESSMENT 27

9.1 TECHNICAL RISK 27
9.2 COST RISK 27
9.3 SCHEDULE RISK 27
9.4 RISK ANALYSIS 27

10. PROJECT CONTROLS SYSTEM 29

10.1 GUIDELINES AND POLICIES 29
10.2 WORK AUTHORIZATION AND CONTINGENCY MANAGEMENT 30
10.3 BASELINE DEVELOPMENT 30
10.4 PROJECT PERFORMANCE MEASUREMENT 31
10.4.1 Funds Management 31
10.4.2 Accounting 31
10.4.3 Performance Measurement and Analysis 31
10.4.4 Schedule Variance 31
10.4.5 Cost Variance 32
10.4.6 Resource Variance 32
10.5 CHANGE CONTROL 32
10.5.1 Out-of-Scope Changes 32
10.5.2 In-Scope Changes 33
10.6 INFORMATION AND REPORTING 37
10.6.1 Project Meetings 37
10.6.2 Reporting 37

11. ACQUISITION STRATEGY PLAN 38

12. ALTERNATE TRADEOFFS 38

12.1 SILICON ALTERNATIVES 38
12.2 CENTRAL PRERADIATOR ALTERNATIVES 38

13. TECHNICAL CONSIDERATIONS 39

13.1 TECHNICAL REVIEWS AND DOCUMENTATION 39
13.2 RESEARCH AND DEVELOPMENT 39
13.3 QUALITY ASSURANCE AND TESTS 39

14. INTEGRATED SAFETY MANAGEMENT 41

14.1 OVERVIEW 41
14.2 OBJECTIVES 42
14.3 ORGANIZATION AND RESPONSIBILITIES 42
14.4 DOCUMENTATION AND TRAINING 42

APPENDIX A: LIST OF REFERENCED DOCUMENTS 44

APPENDIX B: LIST OF SCHEDULE MILESTONES 45

APPENDIX C: QUALITY MANAGEMENT PROGRAM 47

APPENDIX D: CONFIGURATION CONTROL PROGRAM 54

1. INTRODUCTION

This document describes the Project Management Plan for the Run IIb CDF Detector Project.

1.1 Overview of the Project Management Plan (PMP)

This document outlines the objectives of the Run IIb CDF Detector Project. The project management organization is described, participants are named, and a plan is presented to meet the objectives. The Project Management Plan is supplemented with the following documents:

1) The CDF Run IIb Detector Technical Design Report (TDR);
2) The CDF Run IIb Cost and Schedule Plan (CSP), including the CDF Financial Plan;
3) The CDF Run IIb subproject Memoranda of Understanding and work plans (MOU's).
4) DOE Project Execution Plan (PEP) for Run IIb CDF Detector Project and D-Zero Detector Project.

The physics goals of the project are presented in the Technical Design Report. The Cost and Schedule Plan includes a cost estimate for the project and a resource-loaded schedule, both based on a common Work Breakdown Structure (WBS). The full project is divided into four WBS subprojects as follows: SVXIIb; Calorimeter; Data Acquisition; and Project Administration. The MOU's and work plans for each subproject describe all necessary tasks. Appendices to these MOU's reapportion the subproject tasks by institution and indicate explicitly who is responsible for each sub-task.

1.2 CDF Run IIb Detector Project Description

The CDF Run IIb Detector Project prolongs the useful life of the detector for operation at higher luminosity now anticipated at the Tevatron collider. Specifically, the detector must be capable of handling peak luminosity up to 4 x 10^{32} cm^{-2} sec^{-1} and an integrated luminosity of 15 fb^{-1}. Several detector systems must be replaced or modified in order to meet these requirements.

1.3 Historical Background

CDF first detected $\bar{p}$ p collisions in 1985. The detector has collected data in 1987, 1988-89, 1992-93 ("Run Ia") and 1994-1996 ("Run Ib"). Collider Run IIa began in 2001. A large number of important physics results have been produced by CDF and have been published in numerous articles in refereed physics journals. These results include the discovery of the top quark and precision measurements of its mass and production cross section, precision measurement of the W boson mass, a broad program of electroweak measurements, QCD measurements, B physics, including measurement of lifetimes of exclusive states, and Exotic Physics including limits on the production of a variety of non-Standard Model objects.

CDF has gone through periods of extensive upgrades. Between 1989 and 1992, the detector was improved in several ways. This included the addition of a silicon vertex detector, additional muon detectors to increase the muon acceptance, improvements to existing muon systems, and a new inner tracking chamber used to measure the *z* position of event vertices. The experiment recorded 110 pb^{-1} of integrated luminosity during the 1992-96 operating period (Run I).

In October 1990 a proposal was submitted to upgrade the CDF detector to allow it to continue to exploit the physics opportunities as improvements, including the Main Injector, were made to the Fermilab collider. The running conditions for collider Run II specified that the detector must be capable of handling peak luminosity up to 2 x 10^{32} cm^{-2} sec^{-1}, bunch spacing as small as 132 ns, and an integrated luminosity of 2 fb^{-1}. The CDF Run IIa upgrade included replacing the plug and forward gas calorimeters with a new scintillator-based calorimeter and replacing the Central Tracking Chamber with a device with shorter drift time to allow tracking in a high-luminosity environment. A completely new silicon system was built and installed. The front-end electronics and trigger systems were upgraded to accommodate data-taking at higher rates and with shorter bunch spacing. Muon detection systems were upgraded to increase acceptance and allow the electronics to work with shorter bunch spacing. The data acquisition system was upgraded to increase throughput and reliability. A new time-of-flight detector was added, as were new detectors in the forward region. The CDF Upgrade Project for Run IIa was successfully completed in March 2001.

1.4 Reference Documents

Appendix A contains a list of documents referenced in this PMP or which provide direction to the project. References to these documents appear throughout this plan.

2. JUSTIFICATION OF MISSION

The Department of Energy has established the need for the Run IIb CDF Detector Project by completing and approving a Justification of Mission Need (CD-0) document. The scientific objectives of the project were confirmed by the Fermilab Physics Advisory Committee report from June, 2002. The scientific, technical, cost, and schedule objectives pertaining to this project are described in sections 2.1 through 2.4 below.

2.1 Physics Objectives

The primary goal of the CDF Run IIb Detector Project is to enable the detector to exploit the physics opportunities available during Tevatron operation through 2008. The data from Run II will represent a set of detailed measurements that can be compared with the predictions of the Standard Model at the highest available collision energy. The main focus of the experiment in Run IIb will be the continuation of the search for the Higgs boson. The increased size of the data sample will also allow us to study the top quark by measuring the details of its production and decay mechanism. In addition, we plan precision electroweak and QCD measurements, continued searches for a variety of phenomena that are predicted to exist beyond the Standard Model framework, and to explore CP violation in the *b* quark sector. The detailed physics goals of the upgrade are described in the Technical Design Report (TDR).

2.2 Technical Objectives

The major tasks of this upgrade are:

- Replace the silicon micro-vertex detector with a device capable of withstanding the expected radiation dose for Run IIb and with fast r-ϕ (axial) and small angle stereo readout.
- Upgrade the calorimeter by replacing the Central Preradiator Chamber with a device with shorter response time to allow operation in a high-luminosity environment, and adding timing information to the electromagnetic calorimeters.
- Upgrade the data acquisition and trigger systems to increase throughput needed for higher luminosity operation and efficiently trigger on the higher multiplicity events of Run IIb.

The off-line computing hardware and reconstruction software must be enhanced to assure efficient and timely data analysis and production of physics results from the large amount of information that will be accumulated during Run II. Off-line computing and software are managed as a separate project and will be discussed in a separate document. Additional technical detail appears in the CDF Run IIb Detector Technical Design Report.

The installation activities for the Run IIb Detector will be managed as a separate project. Installation will include removing the central detector from the collision hall, extracting the ISL/SVXII detectors from the tracking volume, installing the replacement silicon into the ISL, returning the central detector to the collision hall, and installation of new cabling as required.

2.3 Cost Objectives for the CDF Run IIb Detector Project

The project estimated costs are summarized in Table 5.1 in the PEP.

Financial support for this project includes contributions from CDF's international collaborators (Japan, Italy, Taiwan, Canada, Finland, Korea, Russia, Spain, Switzerland, UK) as described in the CDF Financial Plan. The estimate for international contributions does not include substantial in-kind labor contributions, nor funds contributed for experiment operating expenses.

2.4 Schedule Objectives

The critical objective of the Run IIb CDF Detector Project is to have the upgraded detector ready to install in 2006. Schedule objectives are summarized in the list of milestones presented in Table 8.3 of the Project Execution Plan and Appendix B. The Project is complete when the Run IIb Detector is ready to be installed in the collision hall. The objective is to meet this goal by June 2006.

3. PROJECT DESCRIPTION

The Project is described extensively in the CDF IIb Detector Technical Design Report. A summary description is presented later in this document (Chapter 5: Work Breakdown Structure). The Run IIb CDF Detector Project will be funded through a combination of DOE and international funds. It will be scheduled and controlled under general DOE authority with management of non-DOE elements provided through Memoranda-of-Understanding (MOU's).

The projects needed for Run IIb can be broadly separated into two classes: projects needed due to the increase in instantaneous luminosity, and those needed due to the integrated luminosity and therefore the length of the run required. The former represent an increase in the capability of the detector, beyond the specifications set for the Run IIa upgrade of CDF. The latter are essentially the maintenance costs due to the duration of operation. The Run IIb projects are presented here in three categories: Silicon Detector Replacement, Calorimeter Upgrades, and Data Acquisition and Trigger Upgrades.

The goal of the Run IIb CDF Detector Project is to maintain the viability of the CDF detector as a Higgs search experiment during the Run IIb Tevatron operation.

The trigger efficiencies after the offline analysis cuts for these backgrounds are assumed to scale linearly with that of the signal. We assume the background kinematics is similar to the signal in our approximation. The Higgs search needs the integrated luminosity attainable in Run IIb, and a detector capable of exploiting it fully. The effect of the proposed Run IIb upgrades is summarized here:

- A new silicon vertex detector is the essential element of the Run IIb upgrades, and must deliver a *b*-tagging efficiency of at least 60% of taggable high-E_T jets. A loss of even 10% (to 54%) in this efficiency due to lack of redundancy would cost 20% in required integrated luminosity to discover the Higgs, which translates into 3 fb^{-1} for discovering a Higgs with a mass of 120 GeV/c^2, more than a half year of running time.
- The upgraded detector needs the best possible $b\bar{b}$ mass resolution, and this in turn demands maximal information regarding jet energy flow. The proposed Central Preshower and Central Crack upgrades will enhance the information available in the Run IIa data, and likely lead to a few percent improvement in jet energy corrections overall. This detector improvement is equivalent to several months of running time towards the discovery of the Higgs Boson. The timing upgrade to the electromagnetic calorimeters will reduce cosmic ray backgrounds, and improve the quality of the events that contain photon candidates. This is known to be for important searches in final state channels with photons and missing energy (supersymmetry, anomalous couplings etc). This will provide a vitally important handle that helps confirm that all the photons in unusual events (such as the Run I CDF $ee\gamma\gamma+\not{E}_T$ candidate) are from the primary collision.
- Triggers for the isolated lepton and $b\bar{b} + \not{E}_T$ final states must remain fully efficient at high instantaneous luminosities. Instrumenting the outer Central Outer Tracker stereo layer for use in the trigger decision would limit fakes and aid in hit pattern recognition in

the Secondary Vertex Trigger. We estimate that this upgrade will extend our track trigger effectiveness to the instantaneous luminosities anticipated in Run IIb. Without this upgrade 20% more integrated luminosity is required for the Higgs discovery.

- Finally, the upgrade in bandwidth for the Event Builder from 300 Hz in Run IIa to 1 kHz in Run IIb, along with a complementary upgrade to the TDC system, allows us to retain the high efficiency for the triggers on which the Higgs search is based. A simultaneous upgrade to the Level 3 trigger processors is also required for this higher data collection rate. The proposed 1 kHz system is well-matched to the rates and signal efficiencies of the most important high- P_T physics of Run IIb

Although it is not formally part of the Run IIb CDF Detector Project, the installation of the experiment during the period between Runs IIa and IIb will be managed by the same management structure that is used for the project. The installation subproject involves extraction of the CDF central detector from the collision hall, replacement of the detector components built for Run IIb, and the return of the central detector to the collision hall. This process is essentially identical to the installation performed for Run IIa, so the time and resources required are well understood.

4. PROJECT MANAGEMENT, ORGANIZATION, AND RESPONSIBILITIES

The Fermilab Director carries the prime management responsibility for this project at Fermilab. This project will be carried out in collaboration with the universities and laboratories in the U.S. and other countries that make up the CDF Collaboration. This project will be managed to a predetermined scope, cost, and schedule. Figure 4.1 shows the organization chart for the Run IIb CDF Detector Project. The descriptions presented here serve to clarify the roles of key personnel.

Fermilab and many organizations and institutions external to Fermilab will undertake construction of the components for the CDF Run IIb detector. Significant portions of the detector funding will be provided by sources other than Fermilab. For these reasons, part of the responsibility for construction of detector components will reside outside Fermilab. However, responsibility to the Fermilab Director will be maintained by the CDF collaboration management through the CDF Run IIb Project Manager resident at Fermilab.

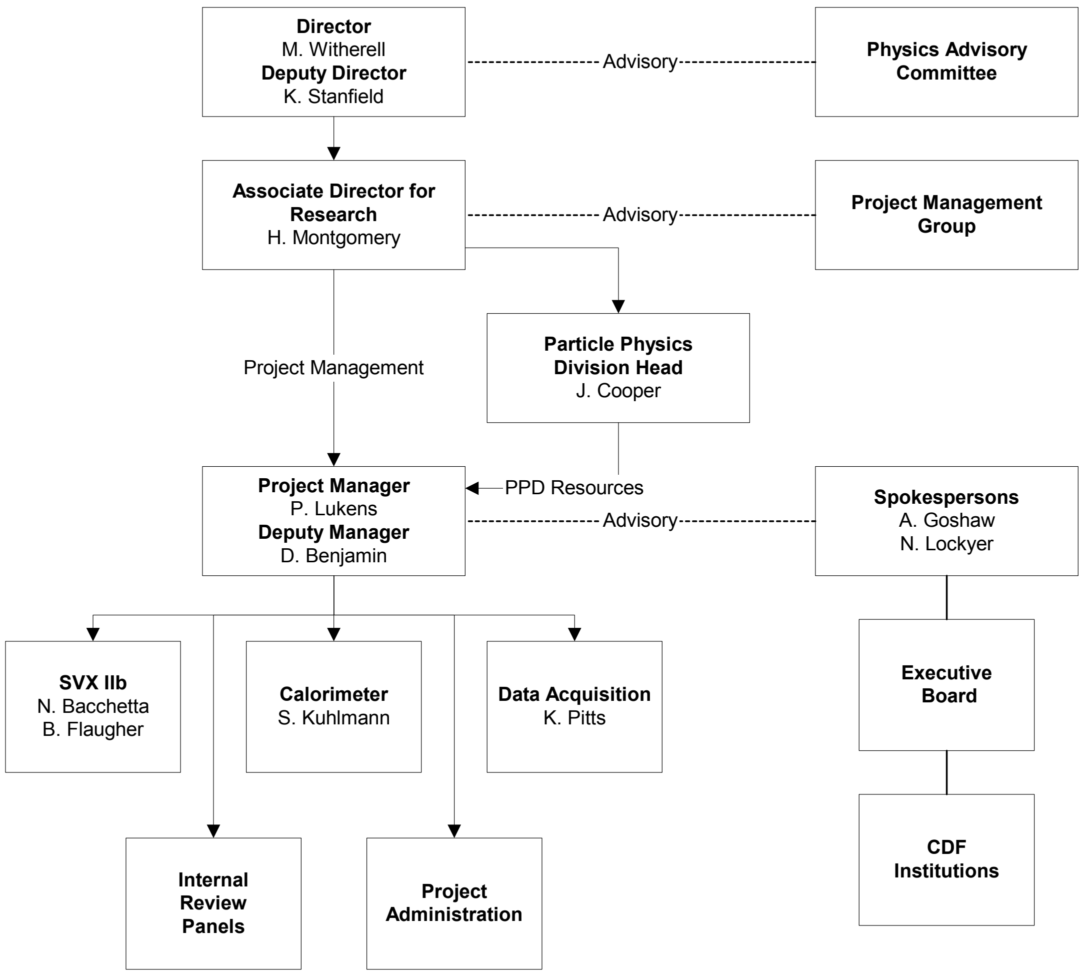
4.1 Department of Energy

As mentioned above, the Department of Energy has established the need for the Run IIb CDF Detector Project by completing and approving a Justification of Mission Need (CD-0) document. The Department of Energy has also participated in peer review processes for the Fermilab program including the annual DOE laboratory-wide review and the Fermilab Physics Advisory Committee meetings. The Department of Energy provides the majority of funding for the Run IIb CDF Detector Project. These funds are provided through the Fermilab annual financial plan by contract modification. The Division of High Energy Physics provides annual program guidance to the Laboratory as well as annual guidance on the funding profile for the project. The Department exercises oversight of the project by:

- Conducting periodic reviews of the project;
- Participating in regularly scheduled Project Management Group (PMG) meetings;
- Overseeing operations and fabrication activities;
- Monitoring project progress via monthly progress reports; and
- Monitoring milestones/performance measures.

The primary contact between the Run IIb CDF Detector Project and the DOE will be the DOE Run II Project Manager. The management structure and roles of the DOE are presented in further detail in section 4 of the PEP.

Figure 4.1
CDF Run IIb Detector Project Organization



4.2 Fermilab Director and Deputy Director

The Fermilab Director has the overall responsibility to the Universities Research Association and the Department of Energy for the successful completion of the Run IIb CDF Detector Project and is the only person authorized to commit funds appropriated for Laboratory use. The Director determines the proposed scope of the upgrade project with advice from the Fermilab Physics Advisory Committee (PAC) in response to proposals from the CDF collaboration. Decisions regarding the scope of the project are made in a two-stage process. Stage I approval is given to endorse the scientific merit of the proposal when sufficient information is known regarding technical designs so that costs and schedules can be estimated. Resources can then be allocated so that a project Work Plan and Memorandum of Understanding (MOU) can be developed, detailed technical designs can be prepared, and cost estimates and resource-loaded schedules can be generated. In addition, a financial plan identifying the necessary funding resources is prepared. Upon the successful completion of these plans, the Fermilab Director may grant Stage II approval. Stage II approval for the project may proceed in parts, subsystem by subsystem. R&D of a subsystem normally begins after Stage II approval has been granted for that subsystem but may proceed earlier with the Director's approval. The Director may at his/her discretion delegate tasks to the Deputy Director.

The CDF Collaboration consults with the Director as part of its procedure for appointing spokespersons. The Technical Design Report, the cost estimate, the schedule, the financial plan for the project, and any out-of-scope changes in the project require the concurrence or approval of the Director.

4.3 Fermilab Associate Director for Research

The Fermilab Director has delegated certain responsibilities and authorities to the Associate Director for Research (ADR). The ADR is responsible for management oversight of the project. The Project Manager is appointed by the ADR and reports to the ADR directly and through the Head of the Particle Physics Division. The ADR chairs the Project Management Group (PMG) that meets as required to monitor the progress of the project. Directorate oversight of the project is implemented in part through reviews including the PMG and Director's reviews. In concert with the routine project management interactions, these reviews will identify actions and initiatives to be undertaken in order to achieve the goals of the project including the allocation of both financial and human resources. The Project Management Group will also function as the Change Control Board for the project. Progress will also be monitored through presentations to and discussions with the PAC.

To implement the work plan for the upgrade project, Memoranda of Understanding are written assigning responsibilities and describing the work to be executed for each subproject. The ADR will approve all Memoranda of Understanding. The ADR is responsible for providing a funding profile consistent with Laboratory funding in consultation and guidance from the DOE Program Office. The ADR assures that the Laboratory long-range schedule and the dates of important project schedule objectives are provided to the Project Manager in a timely manner. The ADR advises the Director on the concurrence and/or approval, as appropriate, of the TDR, the PMP, the cost estimate, the schedule, and the financial plan and concurs with these approvals.

4.4 Fermilab Particle Physics Division Head

The Fermilab Director and ADR have delegated certain responsibilities and authorities to the Fermilab Particle Physics Division (PPD) Head. The PPD Head is responsible for portions of project management and oversight as the line manager for financial resources, human resources, technical resources, space resources, and ES&H issues for this project.

The PPD Head and his/her deputies are members of the Project Management Group. The PPD Head advises the ADR on approval of Memoranda of Understanding relevant to PPD resources and concurs in these approvals. The PPD Head advises the Director and ADR on approval of the

PMP and the CSP and concurs with these approvals. On advice from the Director, the PPD Head allocates yearly budgets to the Run IIb CDF Detector Project. These project funds are then administered by the Project Manager within the context of PPD procedures and policies and with the assistance of the PPD budget office.

Particle Physics Division is the primary source of Fermilab labor and technical resources for the project. The Head of the Particle Physics Division will provide support to the project, in accordance with the CSP, through PPD technical resource groups via specific work plans or Memoranda of Understanding. The Project Manager utilizes assigned personnel to achieve the project goals. The PPD Head maintains line management responsibility for these PPD employees via the technical resource group leaders.

Since the Particle Physics Division is the primary source of Fermilab labor needed to achieve the project schedule goals, any mismatch of labor to the needs of the project must be reported in a timely fashion. The PPD Head or designee will advise the Project Manager and ADR and report to the CDF PMG if insufficient labor is available to meet the requirements specified in the CSP. In this event, the Project Manager will conduct a schedule impact study and submit a schedule variance as appropriate to the ADR as required by the project controls.

4.5 Project Manager

The Project Manager (PM) is appointed by the ADR with the approval of the CDF Spokespersons and the PPD Head. The PM is part of the PPD line management chain at the department head level and has the responsibility to complete the Technical Design Report, the Cost and Schedule Plan, and the MOU/Work Plans for the project. The technical description of the project is that proposed in the Technical Design Report by the CDF collaboration as well as any out-of-scope changes approved via the change control process. As part of the CSP, the PM will provide the Laboratory with labor profiles required to complete the project on schedule. Once the CSP is agreed upon and the necessary resources provided, the Project Manager has the responsibility to complete the Run IIb CDF Detector Project on the agreed upon schedule, and within the agreed upon budget and scope.

The PM is responsible for preparing the Project Management Plan (PMP) and for updating it as necessary with the concurrence of the ADR. The Project Manager may identify the need for project scope changes as they arise. When there is a need for a change having a significant impact on the physics capability of the detector the PM reports to the CDF Collaboration Executive Board and also identifies the need to the Director through the PMG. The PM receives technical advice from Internal Review Committees. The PM creates such committees as needed for technical advice and, in consultation with the CDF spokespersons, appoints their members. The procedure for out-of-scope changes to the project is described in Section 8 of this document. The Spokespersons, representing the collaboration, seek approval for all scope changes having a significant impact on the physics capability of the upgraded detector by making scientific proposals to the Director.

The PM is responsible for organizing presentations at reviews and status reports on the upgrade project to respond to the Director and funding agencies. The PM has the authority to speak for the Collaboration on technical questions raised in these processes. The PM will initiate reviews of upgrade subprojects to insure that adequate progress is being made and that the subproject is meeting its technical performance, cost, and schedule milestones. The PM may request that a godparent review be organized by the CDF spokespersons when questions pertaining to the adequate technical or physics performance of a subsystem are raised.

The Project Manager has the responsibility to complete the Run IIb CDF Detector Project on schedule, on budget, and within the agreed upon scope by managing the resources of the Collaboration and the Laboratory. The Project Manager, in consultation with the CDF Spokespersons and PPD Head, has the authority to appoint deputy and assistant managers as well as sub-Project Leaders (PL). The PM, working with the subproject leaders, is responsible for the completion of the CSP and agreement documents such as the Statement of Work (SOW) and Memorandum of Understanding (MOU) for each subproject. These documents specify the contribution to that subproject from each collaborating institution. The MOU's describe responsibilities for the design, construction and test of new detector components that are a part of this project. Additional MOU's describe work plans for activities that support and maintain existing parts of the CDF detector complex. The MOU's and SOW's are considered to be supporting documents for both the PMP and CSP.

The PM has the authority to negotiate on behalf of CDF with collaborating institutions and Fermilab Section and Division heads for collaboration or Laboratory resources. All negotiations with collaborating institutions will be made in consultation with the Spokespersons. The Project Manager has responsibility for coordinating all collaboration-wide resources for the project via the MOU's. The PM has authority to negotiate with all institutions for optimal utilization and management of these resources. The PM has fiscal authority for U.S. funds and is responsible to the Fermilab ADR through the PPD head for monitoring expenditures of U.S. and international funds as well as tracking and reporting variances from baseline scope, schedule and cost estimates specified in the CSP.

The Deputy Project Manager will have the full authority of the Project Manager, in the event of the PM's temporary absence. The Deputy Project Manger will normally assist in the management of the project.

4.6 Project Leaders

The major sub-projects that make up the detector are shown in Figure 5.1. Each of these sub-projects is headed by one or more Project Leaders (PL). The Project Leaders are appointed by the Project Manager, as described in section 4.6, and report directly to the PM. The Project Leader is responsible for all coordination, tracking, and technical communications involved with the design and production of a subsystem. For subprojects that involve construction of equipment, the Project Leaders are responsible for the design, fabrication, integration, and testing of all components of that particular subsystem. Subsystem fabrication activities will generally be widely dispersed and will involve both the United States and international collaborating institutions.

In some cases, project funds to support the subsystem activities originate with Fermilab and are allocated to subsystem projects on the authorization of the PM. The PM delegates limited signature authority to the PL's for items related to their subproject to be purchased with such funds. In many cases, even though the PL is based in the United States, part of the support will come from international funds. The PL's interact closely with the international leaders of activities relevant to their subsystem to ensure that international funds are appropriately spent on the subproject and to maintain good coordination. The PM does not have budget authority for international funds or for contributions to the project made by collaborating U.S. institutions, but he/she does have the authority and responsibility to ensure that project work at all institutions is technically adequate and within the approved scope of the project. Collaborating institutions agree to the scope, schedule and cost estimate for their work though the MOU process. The PM will interact with the PL's and the representatives of collaborating international institutions to ensure that the distribution of resources is matched to the project objectives and schedule.

It is the responsibility of the PL's to bring to the attention of the PM any anticipated changes in the subproject from the approved baseline that may significantly affect the cost, completion date, or performance of the subsystem. The PL's will provide information on the detailed cost, schedule and performance of the subsystem and will make presentations to review committees, funding agencies, and the directorate when requested to do so by the PM. The PL's may specify Task Managers and appropriate subproject organizations for each subsystem. Further subproject organizational details appear in the subproject SOW's or MOU's. The PL's are responsible for quality assurance and quality control plans for their subprojects and for assuring that their subsystems meet the ES&H standards of Fermilab. Specifically, PL's have responsibility for the following aspects of quality control:

- Incorporation of the necessary design reviews into the project CSP and establishing adequate approval processes prior to procurement and fabrication of subproject components.
- Incorporation of necessary acceptance tests into fabrication plans and practice.
- Verification of system performance requirements.
- Incorporation of sufficient "on-site inspection" at off-site and/or international institutions to assure adequate quality of deliverables fabricated using these sources.
- Documentation and management of records related to the design, development, production, fabrication, installation, operation, servicing, and repair of subsystems.

4.7 Advisory Functions

4.7.1 Project Management Group

The Project Management Group (PMG), chaired by the ADR, brings together for regular meetings, at least monthly, those who have management responsibility for the success of the Run

IIb CDF Detector Project and who have authority to redirect resources within the Laboratory and the Collaboration. The PMG also functions as the Change Control Board for the project.

4.7.2 Spokespersons

The CDF spokespersons are responsible for all scientific aspects of the CDF Collaboration including operation and upgrades of the detector, data analysis, and publication of the results. In this capacity they provide the means of contact between the CDF Collaboration and the Laboratory, and represent the Collaboration in interactions with the Laboratory. The Spokespersons serve as chairs of the CDF Executive Board and are a principal contact point for the PM to communicate and coordinate discussion and review of issues that impact the entire Collaboration. The Spokespersons are elected to two-year terms by the Collaboration with the approval of the Fermilab Director.

4.7.3 CDF Executive Board

The CDF Executive Board advises the spokespersons on scientific and sociological aspects of the collaboration. The Board consists of the Group Leaders (or designates) of each collaborating institution. The Board also approves the addition of new collaborating institutions, as well as significant changes to the detector or the scientific goals of the collaboration. The CDF Executive board is the decision making body that determines the scope to propose to the Laboratory as the Run IIb CDF Detector Project. Decisions by the Executive board are based on consultation with the full CDF collaboration. The Executive board is required to ratify actions by the PM only if the fundamental definition of the Scope of the Run IIb and its physics potential are at issue.

4.7.4 Internal Review Committees

Internal review committees provide a means for the PM to review technical, cost, and schedule issues for upgrade subprojects. These committees may also be charged with reviewing the physics performance of the subsystem or recommending scope changes. Internal review committees are appointed as required by the PM. The PM charges them, often in consultation with the Spokespersons. Reports and recommendations from internal review committees are transmitted to the Project Manager and are in general made available to the entire collaboration.

Internal review committees are also a vehicle for communication between the PM and the Collaboration. In particular, in response to a technical concern raised by members of the collaboration, if the PM has not already done so, the spokesperson may request of the PM that an internal review committee be appointed to provide advice regarding the concern.

4.7.5 Subproject Technical Committees

There may be technical committees associated with a subsystem and separate from the CDF internal review committees discussed above. These are appointed by the PL's as needed. Members of such technical committees advise the subsystem PL on technical directions, alternatives, and methods of performance. The members of the committee would include scientists responsible for the design and fabrication of the subsystem or of major tasks within it. Other technical experts may also be included. The PL chooses the membership of sub-project technical committees. These committees act in an advisory capacity with decision authority in the hands of the PL. Their reports are made available to the Spokespersons, PM, and internal review committees.

4.7.6 Godparent Committees

Godparent committees provide an additional means of reviewing complex technical and physics performance issues. These committees provide additional guidance related to physics goals and a means for collaboration input into the upgrade project. Godparent committees are appointed as required by the spokespersons. The spokespersons charge them, often in consultation with the Project Manager. Reports and recommendations from the godparent committees are transmitted to the spokespersons and the Project Manager.

5. WORK BREAKDOWN STRUCTURE

The technical description of the Run IIb CDF Detector Project is presented in the TDR. The TDR describes the principal components of the detector and serves as reference for the following descriptions of detector subsystems. Detector subsystems are the basis for defining the high-level WBS of the detector upgrade project. The WBS to level 2 is shown in Figure 5.1. The task-based WBS extends to many levels to facilitate planning, scheduling and cost estimation. Detailed cost estimates and the resource-loaded schedule are contained in the CSP. The resource-loaded schedule in the CSP provides the basis to track project cost, estimate future labor requirements and financial needs, document project changes, and estimate the project completion date. Provided below is a description of the project at WBS level 2.

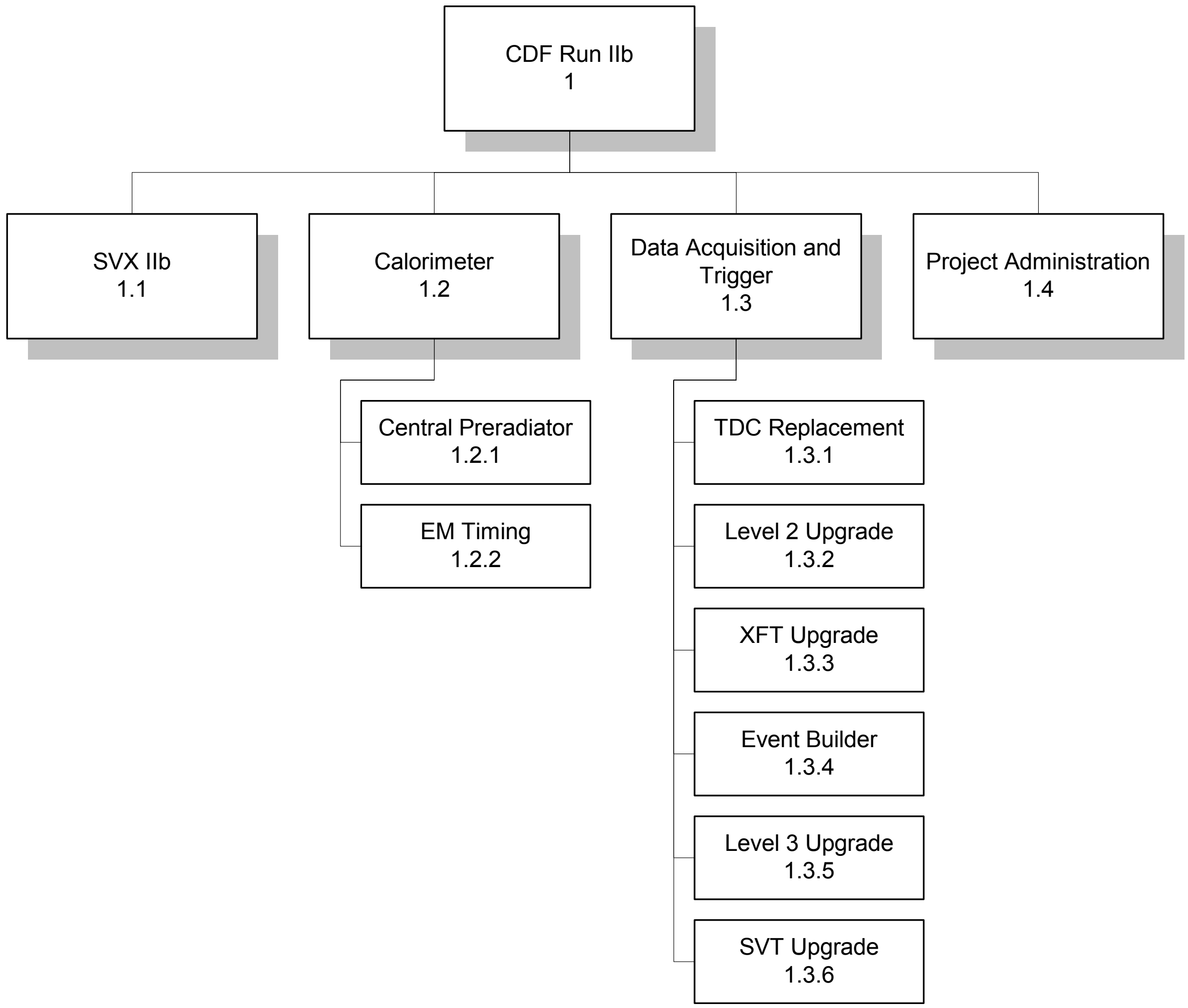
5.1 SVXIIb

WBS 1.1 includes work to build a new silicon vertex detector, called SVX IIb. The CDF collaboration has considerable experience with state-of-the-art silicon detectors. The original SVX was implemented in a "radiation-soft" technology and as expected suffered considerable radiation damage before the end of Run Ia. Between Run Ia and Ib, the SVX detector was replaced with a new device, SVX', of nearly identical geometry but using AC-coupled silicon detectors and a radiation-hard readout chip. The SVX' was replaced for Run IIa (SVX II). The SVX II detector was designed to address several shortcomings of the SVX'. The barrel (central) region is longer to cover the luminous region with higher efficiency. This substantially increases the b-tagging efficiency for top decay. The detectors are double-sided to provide *r-z* readout for pattern recognition. SVX II was designed to withstand much larger radiation doses. The readout chip is pipelined for 132 ns bunch spacing. SVX II, in combination with additional Layer 00 system has six layers for improved pattern recognition.

Radiation damage from Run IIa will render the inner layers of the silicon vertex detector inoperable. The main upgrade for Run IIb, a new inner silicon vertex detector, is needed in order to maintain excellent *b*-jet triggering and reconstruction. For the Higgs search the key design goals for this detector are to meet or exceed a 60% *b*-jet tagging efficiency per taggable jet at high P_T, using secondary vertex reconstruction, and to maintain high efficiency in the silicon vertex trigger (SVT).

SVXIIb will consist of single-sided silicon detectors that are easier to manufacture than the double-sided detectors used in SVX II. The design uses a single mechanical structure throughout which reduces both construction time and cost. The readout chip (“SVX4”) will be manufactured in a standard process to minimize costly schedule delays. Both the DAQ and cooling systems will be retained from SVX II.

Figure 5.1
CDF Work Breakdown Structure



5.2 Calorimeter

The Calorimeter work shown in WBS 1.2 includes the Timing upgrades and the Central Preradiator replacement as explained below.

5.2.1 Central Preradiator System

WBS 1.2.1 is the Central Preradiator (CPR) Replacement. The current preradiator chamber system is a gas-based chamber with wires running the length of the wedge. It increases the experiment's power to discriminate between photons and high transverse momentum π^0's. Because the gas chamber system contains data from several bunch crossings, the high luminosity environment anticipated for Run IIb will give the CPR an extremely high occupancy and these chambers will not be able to effectively deliver useful information. The gas chamber system will be replaced by a scintillator system whose timing characteristics are more appropriate for the bunch crossing time used in Run II.

The preradiator plays a key role in high P_T photon and electron identification, and in correcting for energy lost by particles showering in the 1.1-interaction-length magnet coil. Studies have shown that for the electromagnetic fraction (30%) in typical jets, an efficient and pure preradiator signal can improve electromagnetic resolution by 20% and may provide an overall improvement in jet mass resolution of a few percent. This is an important part of the overall 30% improvement over Run I that is needed. Identification of electrons in jets can also aid in identifying and correcting the energy of *b* quark jets, which is crucial for the Higgs search.

The existing crack chambers will also be replaced with scintillator-based detectors as part of the CPR upgrade. These would add to the array of information useful to correct the $\not{E}_T$ measured by the calorimeter and to correct jet energies for losses in the cracks.

5.2.2 EM Timing

WBS 1.2.2 covers instrumentation of the electromagnetic calorimeter with timing capability similar to that which is already in place for the hadronic calorimeters. Experience with the Run I data indicated that timing information is an important technique for reducing backgrounds due to cosmic rays. Cosmic ray backgrounds can be significant in searches for exotic final states that contain photons and missing transverse energy. The EM Timing project will provide a vitally important handle that helps confirm that all the photons in unusual events are from the primary collision.

5.3 Data Acquisition and Trigger Systems

WBS 1.3 includes modifications to the Data Acquisition and Trigger systems. These modifications are proposed both to maintain the existing capability of the systems and to upgrade to higher bandwidths for Run IIb. Replacement of the processors used in the online system, the level 2 trigger, and the level 3 trigger are anticipated just to maintain the existing system. System upgrades needed in order to handle the Run IIb instantaneous luminosity include an improvement to our track based trigger, an upgrade to the event builder switch, and a replacement for the time-to-digital converters used in the drift chamber (COT).

5.3.1 Event Builder

WBS 1.3.1 covers the upgrade of the event builder portion of the data acquisition system. This system acquires the digitized data from front-end electronics and delivers it through a high-level processor farm (Level 3 system) where the final decision is made to write data to tape and/or the on-line monitoring programs. The upgraded system is designed to deliver events at the rate of at least 1000 Hz to the Level 3 trigger system with a negligible system dead time beyond that due to the Level 2 hardware trigger decision time and front-end digitization time.

The maximum bandwidth theoretically achievable with the existing Run IIa system is 240 MBytes/s. In practice, about 60% of this limit has been achieved in benchmarking tests with simulated data sizes corresponding to the expected detector occupancy. It is possible that the performance under test conditions can be further improved to about 80% of the theoretical limit after tuning the system. The performance when processing real data on the other hand depends crucially on the load balancing among the various ATM switch inputs and it is desirable to assume that at best 50% of the theoretical bandwidth can be used.

To match the requirements corresponding to a sustained data rate of at least 250 MBytes/s the existing system is not sufficient and an upgrade is necessary. For the upgrade, a sustained bandwidth of at least 400 MBytes/s is required to take into account load imbalance in the ATM inputs and fluctuations in the data size.

A simple, straightforward upgrade scenario is proposed, in which the same technology is used. The existing ATM switch uses OC3 connections, which are upgraded to the four times more powerful OC12 connections. This also implies a complete replacement of the switch. The main work will be to rewrite the low level drivers.

5.3.2 Track Trigger Upgrade

The CDF Level-1 track trigger (XFT), which can be applied to ~80% of all Run IIb triggers for high P_T physics, suffers from a rapid increase in fakes once the number of overlapping minimum bias events exceeds something like 5-6 interactions per crossing. CDF has applied the full Level-1 track trigger hardware simulation to a sample of $t\bar{t}$ Monte Carlo Events. Minbias events are overlapped and the fake rate is determined. It is found that the fake rate increases substantially as a function of the number of interactions per crossing. The impact of an increased number of fakes directly affects the number of fake single electron and muon triggers, which combine to use 25% of the trigger bandwidth in Run IIb.

5.3.3 Replacement of the TDCs

The time to digital converters (TDCs) currently in use for the Central Outer Tracker (COT) have an inherent limitation to their speed of readout, that limits their use to a 300 Hz accept rate of Level 2 triggers. We predict that the Run IIb operation conditions will require the experiment to accept Level 2 triggers at 1000 Hz to maintain the physics goals of the experiment. Replacing the TDCs will be necessary to achieve this.

5.3.4 Replacement of the Level 2 Decision Crate

The Level 2 decision crate contains the processors that form the Level 2 trigger decision. This crate and its processors is based on technology that is no longer commercially supported, and is unlikely to remain viable for the duration of the run. Replacement of this device during the course of the run is anticipated.

5.3.5 Replacement of the Level 3 Processors

The computers used in the Level 3 trigger will be replaced in batches during the course of the run. The new processors installed for this replacement will have greater capability, which will be required for the complex events that will be obtained at high luminosity.

5.4 Project Administration

WBS 1.4 includes work required for project administration. The tasks include but are not limited to technical oversight and management of the project, cost and schedule estimates, construction of work plans/ MOU's, planning and assistance in the administration of international funding, communication and liaison with the Laboratory management, cost and schedule tracking, funding profiles and projections, contingency analysis, procurement support, change control documentation, and preparation for project reviews or status reports. This WBS element includes the salaries of administrative and management personnel involved in these tasks and the cost of necessary computing equipment to support project administration.

Consistent communication on upgrade activities is maintained throughout the CDF collaboration using Electronic mail, the World Wide Web, video-conferences, frequent subsystem and collaboration meetings, and periodic subproject progress reviews (mini-reviews). These ensure good coordination of the overall project.

6. RESOURCE PLAN

The resource plan is included in the Run IIb CDF Detector Cost and Schedule Plan. A summary of the anticipated funding for the project can be found in Table 6.1 of the PEP.

6.1 Equipment Resources

All materials, services and technical labor is included in the cost plan described in the PEP. The majority of this cost will be covered by the DOE, although significant contributions are anticipated from Japan and Italy.

6.2 Personnel Resources

A significant amount of uncosted labor is required for the project. This labor pool will come from the physicists within the CDF collaboration. At the height of the project, the project will require approximately 20 full time equivalent physicists for the construction and testing of new detector systems. This is well within the capacity of the CDF collaboration.

7. TECHNICAL, SCHEDULE, AND COST

The technical description is presented in the CDF IIb Technical Design Report. Cost and Schedule details are described in the CDF IIb Cost and Schedule Plan (CSP). The methodology used to develop the project schedule is to construct a task-based, resource-loaded schedule for each upgrade subproject and then combine these schedules for the entire upgrade project. This combined schedule provides the means whereby the required funding and labor requirements for the entire project can be assessed and best matched with the resources available from Fermilab, other collaborating institutions, and other sources. Critical path analysis is done both at the subproject level and for the project as a whole.

Value Management (VM) principles are essential to proper program management and have been incorporated at the early design and development stages of the technical requirements. These principles have also employed as the cost and schedule parameters matured over time. Use of the VM approach provides a systematic framework to analyze the functions of systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with required performance, quality, reliability and safety. VM elements have been incorporated as a part of each of the technical and program reviews to date.

In the CSP, each sub-task is described in a WBS dictionary for each subproject. The dictionary contains details of the cost estimates and provides a contingency analysis for that sub-task. The CSP contains a list of critical milestones. These milestones are incorporated into the resource-loaded schedule and will be used to track the progress of the project. DOE Level 0 and 1 milestones are contained in the PEP and Level 2 as an appendix to this document.

Contingency is estimated at the lowest level WBS item within the project. The level of contingency is established by the Level 2 managers. Basic guidelines for the assignment of contingency are outline in Table 7.1, although other values will be used as appropriate.

Description	Contingency Level
Item is Completed	0
Purchase Order has been placed	10%
Engineering estimate, based on design and vendor information	30%
Physicist estimate, based on a conceptual design.	50%
Incomplete estimate, based on experience	100%

Table 7.1 Contingency assignment guidelines

8. CHANGE CONTROL THRESHOLDS

The thresholds for change control are detailed below for the Run IIb CDF Detector Project in Table 8.1. The CDF PMG functions as the Change Control Board for the project. The CDF Project Manager will maintain current records of each Change Request (CR) and their disposition. DOE Change Control authorities are outlined in Table 8.1 of the PEP. A sample CR is shown in Figure 10.2.

	Fermilab Director/Deputy Director	**CDF RUN IIb Project Manager**
Technical	Changes that affect ES&H requirements or impact accelerator systems. Out-of-scope changes to upgrade physics capabilities.	Changes that do not affect ES&H requirements and do not change upgrade project scope.
Cost	Any increase in a level 2 subproject by $100K.	Any use of contingency.
Schedule	Any change in the project critical path or a Level 2 milestone.	Any change in a sub-system critical path or Level 3 or 4 milestone by more than 1 month.
Personnel	Any increase in required Fermilab project personnel of 10% relative to CSP.	Any change in level 2 subproject personnel of 10% for the year.

Table 8.1 Baseline Change Approval Thresholds

9. RISK MANAGEMENT ASSESSMENT

Detector upgrades are well within the experience and expertise of the CDF collaboration. Every effort has been made to specify these projects in a manner that reduces the level of risk to an acceptably low level. Several steps will be taken to assure that the risk to this project is low.

9.1 Technical Risk

Preparation of clear and concise specifications, judicious determination of subcontractor responsibility and approval of proposed lower tier sub-subcontractors, and implementation of QA provisions will minimize technical risk. Projects have been designed to further minimize technical risk by exploiting previous experience to the greatest extent possible, and minimizing exposure to single vendor failures.

Making deliberately conservative design choices has minimized technically risky elements of the silicon detector. Use of single sided sensors, reduction in component variety, and common integrated circuit technologies will reduce risk.

9.2 Cost Risk

Use of fixed-price subcontracts and competition will be maximized to reduce cost risk.

9.3 Schedule Risk

Schedule risk will be minimized via:

- Realistic planning,
- Verification of subcontractor's credit and capacity during evaluation,
- Close surveillance of subcontractor performance,
- Advance expediting, and
- Incremental awards to multiple subcontractors when necessary to assure total quantity or required delivery.

Incentive subcontracts, such as fixed-price with incentive, will be considered when a reasonably firm basis for pricing does not exist or the nature of the requirement is such that the subcontractor's assumption of a degree of cost risk will provide a positive profit incentive for effective cost and/or schedule control and performance.

9.4 Risk Analysis

Risk to the project will be evaluated by following a method outlined in A Guide to the Project Management Body of Knowledge. Two risk related quantities are estimated for each significant element of the project, an impact factor, and a risk probability. The impact factors are described in Table 9.1.

Table 9.1 Evaluating Impact of a Risk on Major Project Objectives

	Very Low Risk 0.05	**Low Risk 0.1**	**Moderate Risk 0.2**	**High Risk 0.4**	**Very High Risk 0.8**
Cost Objective	Insignificant cost increase	< 5% Cost increase	5-10% Cost increase	10-20% Cost increase	> 20% Cost increase
Schedule Objective	Insignificant schedule slippage	Schedule slippage < 5%	Overall Project slippage 5-10%	Overall Project slippage 10-20%	Overall Project slippage > 20%
Scope Objective	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Project scope reduction unacceptable for physics objectives	Scope of project effectively useless for mission
Technical Objective	Technical degradation of project barely noticeable	Technical performance of final product minimally affected	Technical performance of final product moderately affected	Degradation of technical performance unacceptable for physics objectives	Technical performance of end item effectively useless for mission

Table 9.1 Evaluating Impact of a Risk on Major Project Objectives

For each item within the project, an estimate will be made on the nature of the risk this item presents to the project as a whole. The impact for each of the four categories given in Table 9.1 will be considered. The probability of occurrence (cost overrun, schedule slippage, etc.) will also be estimated. The product of these two quantities will is the risk factor. Mitigation strategies will be considered for any moderate or high risk items in the project, currently estimated as a risk factor of 0.15 or greater.

10. PROJECT CONTROLS SYSTEM

This section summarizes the management systems that the CDF Run IIb Project Manager will use to manage the cost and schedule performance and the technical accomplishments of the Project. The significant interfaces that exist among the various management systems are noted in the individual narrative descriptions below. Although these systems are described separately they are mutually supportive and are employed in an integrated manner to achieve the project objectives. As conditions change during the evolution of the project, the management systems will be modified appropriately so as to remain responsive to the needs for project control and reporting. Consequently, while the policy and objectives of each management system will remain fixed, the methods, techniques, and procedures that will be employed by the Run IIb CDF Detector Project may change as conditions dictate, over the life of the project.

The Work Authorization and Contingency Management System and the Project Control System described in this chapter constitute the required management and control procedures.

10.1 Guidelines and Policies

The Contingency Management System and the Project Control System employed by the Run IIb CDF Detector Project will be consistent with the Fermilab "Project Control System Guidelines", dated May 1, 1994.

The following policies are applicable for the CDF Run IIb:

- All Project work is organized in accordance with the Work Breakdown Structure.
- Formal (and informal) reviews by experts are used to obtain specifications and designs.
- Established cost, schedule, and technical baselines are used for measuring project performance. The technical baseline for the project is described in the Technical Design for each system included in the scope of the upgrade project.
- Changes to the approved cost, schedule, and technical baselines proceed via a Change Request (CR) process described below.
- A project management system, which features performance measurement and critical-path scheduling, is used to control the project and to provide forecast and feedback information to management.
- The decision-making apparatus employs regular meetings among the Run IIb CDF Detector Project organizational elements. These meetings serve to identify and resolve interface issues within the project.
- Quality assurance, safety analysis and review, and environmental assessment are integral parts of the Work Authorization and Project Control.

10.2 Work Authorization and Contingency Management

The Director will make funds available to the Run IIb CDF Detector Project on an annual basis following the receipt of the Initial Financial Plan from DOE. These funds will correspond to a financial plan and a funding profile to project completion as determined by the Director. The funding profile will include contingency in each year of the project.

Cost accounting will follow the WBS structure. The accumulation of M&S costs will be initiated through purchase requisitions originating with the engineering and scientific staff assigned to the various sub-systems. Signature authority levels will be provided to the Fermilab Business Services Section by the CDF Run IIb Project Manager to assure that only authorized work is initiated. Labor costs are also tracked but at a higher level of the WBS.

At any time the project contingency is the difference between the project Total Project Cost (TPC) and the sum of the current Estimates at Completion (EAC) at level 2 of the WBS. The Project Manager will hold the contingency and allocate it subject to the project change control described below.

The principles of contingency management that the Run IIb CDF Detector Project will follow are as follows:

- The cost estimate for each sub-system will include contingency funds based on an assessment by the preparer of uncertainties and risks associated with the budgeted cost.
- The actual expenditure of contingency will be reflected in a new EAC to be updated every 3 months.
- Contingency funds are allocated as needed throughout the year, within the following guidelines:
    - The PM may adjust the estimated cost of any WBS level 2 subproject by as much as $100K, as long as the Project TEC is not exceeded. If the estimated costs of any WBS level 2 subproject increase by more than $100K, a change request shall be submitted, as described in Section 10.5.2 (In-Scope Changes) below.
    - Use of contingency above the amount budgeted for the year requires approval of a change request.
    - Any unused contingency can be used to fund tasks scheduled for subsequent years.

10.3 Baseline Development

Baseline Development includes management actions necessary to define project scope and responsibilities, establish baselines, and plan the project. Each upgrade subproject prepares a formal cost estimate and schedule. These are included in the CDF Run IIb Cost and Schedule Plan. The subprojects all have defined Work Breakdown Structures (WBS) which are detailed subsets of the WBS presented in Figure 4.1 of this document. In addition, technical specifications for each subproject are contained in the CDF Run IIb Detector Technical Design Report.

10.4 Project Performance Measurement

Project Performance includes management actions after work commences that are necessary to monitor project status, report and analyze performance and available resources, and manage risk. Project performance aspects of the Project Control System consist of the following:

10.4.1 Funds Management

The cost plan for the project is based on the Laboratory's funding profile. This plan reflects the best estimate of funding levels and the baseline schedule. Changes in the Laboratory funding profile may affect the overall cost and schedule for the project. Each year, subproject budgets are set based on the current funding profile guidance. The Project Manager and Project Leaders adjust the resource-loaded schedule so that the available funding is distributed optimally balancing cost and schedule considerations.

10.4.2 Accounting

The actual cost of the project is captured in the Laboratory's General Ledger and is tracked by the Work Breakdown Structure. Summary and detailed cost reports are prepared each month by the Project Management. Monthly reports of costs and obligations for capital equipment funds are submitted to Laboratory management and the Department of Energy through the Laboratory Financial Information System and the Cost Budget Report prepared by the Laboratory accounting department. Information for the Run IIb CDF Detector Project is reported by Budget and Reporting (B&R) Code and by Budget Reference Number (BRN).

10.4.3 Performance Measurement and Analysis

The principal functions of performance measurement and analysis are to identify, quantify, analyze, evaluate and rectify significant deviation from the baseline plan as early as possible.

10.4.4 Schedule Variance

At the end of each month, the milestone list and critical path tasks will be evaluated to identify deviations from the baseline schedule. Any deviations that have a significant impact on the project, either by delaying completion or by affecting the cost or labor plan of the project will be identified. A plan to rectify any delays will be developed and may include either alteration of the project schedule to optimize work and reduce delay or allocation of additional resources to shorten the time required to perform the tasks involved.

Any change that would alter the schedule, cost or required labor resources will be subject to change control as described in this plan.

10.4.5 Cost Variance

Monthly cost variance will be determined by comparing the actual cost of work performed at WBS level 2 with the budgeted cost of work performed as represented in the current EAC. Cost variances that exceed the established thresholds are formally reported as required in this plan.

10.4.6 Resource Variance

A monthly analysis of the resources available (labor and funds) will be performed to ensure that shortfalls in either which could lead to schedule and/or cost variances are identified in a timely manner and brought to the attention of the PMG.

10.5 Change Control

Change Management includes management actions necessary to ensure adequate control of project baselines, including the performance measurement baseline. Documentation of the changes and their impacts are recorded as part of the Configuration Management Program found in Appendix D. Change Management aspects of the Project Control System consists of the following:

10.5.1 Out-of-Scope Changes

An Out-of-Scope Change is a proposed change to the Run IIb CDF Detector Project that would alter the physics capabilities of the detector in a major way or introduce a new detector system. This will include any change to the project for subsystems whose scope has not been completely specified. Any change to the Run IIb CDF Detector Project outside the Laboratory approved scope must be initiated by a formal proposal to the Director for consideration. The scope of the project includes the design, construction, and installation of the collection of systems or improvements to systems, proposed to the Laboratory for approval as part of the Run IIb CDF Detector Project, that have been granted Stage I approval by the Director. The initial scope of the project is described in the TDR.

The procedure for Out-of-Scope changes is described schematically in Figure 10.1. An Out-of-Scope Change begins with a CDF note and presentation at a CDF Run IIb meeting. The Project Manager who, in general, will seek advice from the Project Leaders and other technical experts, reviews the proposed change. The PM may also seek advice from a CDF Godparent committee or Internal Review Committee. The PM may request that the proponents of the Change prepare an Impact Statement that identifies the Performance, Cost, and Schedule impact of the proposed Change. Following the Project Manager's review of the proposed change the PM makes a recommendation to the CDF Executive Board. If the recommendation of the PM is to proceed with the change and the Executive Board ratifies the recommendation, the proposed change, including the effect on the CSP, is presented to the CDF Project Management Group.

In response to an Out-of-Scope change proposal the Fermilab Director may seek the advice of Fermilab's Physics Advisory Committee, the CDF PMG or a Director's review. The proposed change can be granted Stage I approval; deferred for further clarification of the physics potential, technique, cost and/or schedule; or it may be rejected.

10.5.2 In-Scope Changes

Any change to the Run IIb CDF Detector Project that does not alter the Scope of the Project as defined in 10.5.1 above does not require a new proposal to be submitted to the Laboratory. Although the scope of the project is not affected, changes resulting in cost variations, changes of personnel assignments, or schedule impact are considered In-Scope Changes. Table 8.1 summarizes In-Scope Change control thresholds and responsibilities. All changes from baseline cost shall be traceable. Each In-Scope Changes must have the approval of the CDF Run IIb Project Manager before Contingency Funds are authorized and allocated to cover the changes. The CDF Run IIb Project Manager is responsible to maintain a record of all Change Requests and all records of the Run IIb CDF Detector Project documentation revision status.

The CDF PMG functions as the Change Control Board for the project. The Directorate will maintain the records of CDF Run IIb Project Management Group meetings. In-Scope Changes that result in increases above the following thresholds will require the approval of the Deputy Director and/or Director and must be initiated by a Change Request (CR) form. Each of these requests must be presented at the CDF PMG. Thresholds for these requests listed below and in Table 8-1:

- Any increases to the CDF Run IIb Project Estimate at Completion
- Increases in any level 2 WBS element greater than $100,000
- Any increase of Fermilab personnel resources by 10% for any level 2 system above that indicated by Cost and Schedule Plan

In-Scope Changes that result in a schedule change such that the Baseline Schedule Objectives for project completion cannot be met must be reported to the Director. Any proposal that results in a change of a milestone held by the Director or DOE shall be submitted for approval to the CDF PMG via the Change Request process and reported to the Director. The response to such a CR may be to initiate plans to reallocate resources to recover the schedule, to stage or descope the detector, or to revise project Schedule Objectives.

Figure 10.1
CDF Run IIb Out-of-Scope Changes

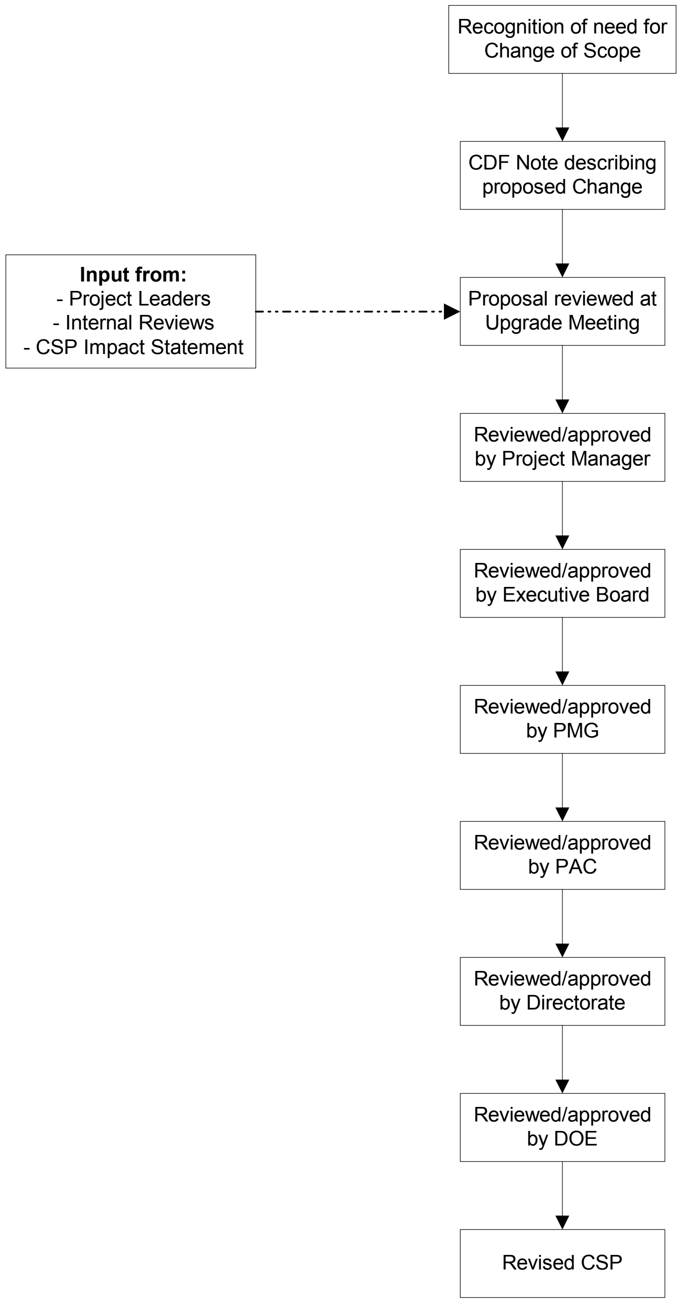


Figure 10.2
CDF Run IIb Change Request

CDF RUN IIb **Change Request**	Date: Rev Date:	Change Request #:	Page ____ of _____
Title:			
WBS:			
Affected Items:			
Originator:	Email:		Phone:

CCB DISPOSITION **DATE**	**Approval:**
Accepted · Rejected · Forward to Director ·	CDF PM _______________ Date __________
Chairperson:	ADR _______________ Date __________
	DOE PM _______________ Date __________

Summary:
- A very brief, simple paragraph will provide the following:
- What's being requested
- Why it's necessary
- What it costs and the impact on other costs
- When it will be done and the impact on the schedule
- Other pertinent information if necessary

Part I: Technical
- Problem or reason for the change
- Description of proposed change
- Analysis showing that the change will solve the problem, add to the capability, or reduce cost
- Impact on interfaces with other elements
- Alternatives considered
- Impact if Change is not approved

Part II: Schedule
- Justification for requested schedule change (if not previously covered)
- Impact to the time phasing of budget (if none, so state)
- Impact to any Level 2 or Level 3 milestone(s) (if none, so state)
- Impact to interfaces; other activities (if none, so state)

Part III: Cost
- Cost estimate, current budget available, and delta cost

Part IV: Work Breakdown Structure (WBS) & Dictionary
- WBS elements to be added/deleted, including identification of cost accounts
- Justification for the requested WBS change, if not already covered
- Impact to cost and schedule if not already covered.
- Changes required in the WBS Dictionary

Part V: ES&H Impact
- Indicate any ES&H impact

Part VI: Labor
- Impact on Labor required (if none, so state)

Figure 10.3
CDF Run IIb Document Change Notice (DCN)

CDF RUN IIb **Document Change Notice**	Date: Rev Date:	DCN #:	Page ____ of _____

Title:		
WBS:		
Document, System, or Component:		Previous DCN # (if applicable)
Originator:	Email:	Phone:

CCB DISPOSITION **DATE** Accepted · Rejected · Forward to Director ·	**Hardware change**	**YES**	**NO**
	Software change	**YES**	**NO**
Chairperson:	**Record change only**	**YES**	**NO**

Change Description (From/To): • A brief paragraph should describe the original configuration and the existing configuration:

Serial or ID#'s of affected systems or components:

Retesting requirements:

Acknowledgements/Completed Actions:	
Originator:	**Document Manager:**
Level 2 Manager:	**CIDL Update Complete:**
Project Manager:	**Other (Specify):**

10.6 Information and Reporting

10.6.1 Project Meetings

The Run IIb CDF Detector Project group leaders meet every two weeks to discuss progress on upgrades and issues of interest across subsystem boundaries. There is a general upgrade collaboration meeting held weekly. Minutes of these meetings are kept. The Project Management Group also meets bi-weekly. Progress on upgrades is presented to the collaboration at collaboration meetings four times per year. The individual upgrade projects all have meetings of their own, typically weekly. Additional meetings will be scheduled as needed.

10.6.2 Reporting

Project leaders review their schedules monthly. This includes an assessment of task scheduling and estimated costs. Updated resource-loaded schedules are submitted by the PL's to the PM. The Project Manager prepares monthly progress reports to the Director including a brief narrative technical section and a consolidation of the subproject cost and schedule status. CDF Run IIb monthly progress reports will be submitted to the DOE Run II Project Manager by the Fermilab Directorate.

Run IIb CDF Detector Project subsystem leaders give status reports about once a month at the collaboration upgrade meeting. Copies of transparencies presented at these meetings provide a written record of subproject progress on this time scale. Minutes are also kept for these meetings. Quarterly written progress reports are submitted to the PM by the PL. These narratives contain a description of technical progress that is more detailed than that submitted monthly.

Progress on the Run IIb CDF Detector Project is reported to the Fermilab Directorate and DOE Project Manager via presentations to the PMG, director's reviews, and Physics Advisory Committee. Subsequent progress on the upgrade project will be reported at periodic DOE reviews. The DOE also provides representatives to the Fermilab PAC meetings.

11. ACQUISITION STRATEGY PLAN

The acquisition strategy is discussed in a separate document: "Acquisition Execution Plan [for] Run IIb CDF Detector Project and Run IIb D-Zero Detector Project at Fermi National Accelerator Laboratory".

12. ALTERNATE TRADEOFFS

12.1 Silicon alternatives

Single sided silicon strip detectors will be used in the silicon project. Early considerations for this detector included silicon pixel detectors, but those were rejected as being an immature technology, considering our schedule requirements. Silicon strip detectors are the only other technology we can consider that will meet our specifications for performance and radiation resistance. Several variations of the silicon detector layout have been considered. The detector described in the Technical Design Report is a compromise between performance and cost.

12.2 Central Preradiator Alternatives

Scintillator was the only technology considered for the preradiator, since it will meet the specifications at a reasonable cost. Various methods of light collection have been studied, and the final design is based on an optimization, balancing performance and cost.

13. TECHNICAL CONSIDERATIONS

Technical considerations are presented and examined in detail as part of the Technical Design Report (TDR). A brief summary of the research and development considerations is presented below as well as the approach and responsibility for assurance of quality.

13.1 Technical Reviews and Documentation

The collaboration, through internal reviews and godparent committees, evaluates the plans for the upgraded detectors. Periodic reports on prototype and pre-production devices as well as computer-simulated performance of the final detectors are critically examined to assure that the upgraded detector will meet the CDF physics goals.

The planned detector upgrades and their performance are documented in the TDR. This document is controlled as part of the Configuration Management Program (Appendix D) and defines the baseline upgraded CDF detector. The TDR is reviewed by the Fermilab Physics Advisory Committee and by the Department of Energy as part of establishing the baseline cost and schedule for the upgrades. Work plans and MOU's, which specify how the work will be carried out and include responsibilities for testing and documentation, are written and agreed to by participating entities. QA documentation is considered one of the deliverables for project components whether built at Fermilab or at other institutions.

13.2 Research and Development

Subsystems and their components are designed to meet the requirements outlined in the TDR. Research and development is performed on detector components to ensure that the chosen technology will meet the physics and engineering requirements of the detector and will achieve the technical and reliability requirements needed for operation at the upgraded Tevatron. Designs are documented in design reports and drawings are checked by peers, senior engineers, and/or managers. Design reviews are performed as outlined in Section 6. Design reports, specifications, drawings and other documentation will be delivered to Fermilab to ensure that detector components can be supported and maintained.

13.3 Quality Assurance and Tests

Quality Assurance and Quality Control (QA/QC) systems are designed, as part of the Quality Management Program, to ensure that the components of the detector meet the design specifications and operate within the parameters mandated by the requirements of the High Energy Physics Program. The Quality Management Program can be found in Appendix C of this document. The QA/QC elements currently in place for the Run IIb CDF Detector Project draw heavily on the experience gained from past detector construction projects. Senior management recognizes that prompt identification and documentation of deficiencies, coupled with the identification and correction of the root causes, are key aspects of any effective QA/QC

Program. The Project Manager endorses and promotes an environment in which all personnel are expected to identify nonconforming items or activities and potential areas for improvement.

Detector components are fabricated specifically for CDF by either commercial vendors, other Department of Energy Laboratories, member universities within the CDF Collaboration, Fermilab owned facilities, or some combination of the above. The items manufactured may be individual components, detector sub-assemblies, or a complete piece of upgraded equipment being installed as part of the Project. One example of a complete assembly would be the Electromagnetic Timing Project, or EM Timing, supplied by Italy and Texas A&M University. It is the responsibility of the Project Manager and/or Project Leaders to have adequate verification methods in place to assure that only properly trained, qualified, and certified personnel are involved in the design, manufacture, and installation of detector components.

All components must be fabricated to pre-determined design specifications that will allow them to operate properly when integrated into the total system. Agreements are in place with each vendor that explicitly state the operating parameters of the piece or pieces they construct. These agreements also assign the responsibilities for testing and verification of the final product. Procured items must meet established requirements and perform as specified. In some cases, random testing of a certain percentage of components will be performed and documented by an independent organization. One example of this approach for the more specialized and expensive components is the Tsukuba verification of the Hamamatsu sensor specifications. In the event that non-conforming items are discovered, they will be documented and controlled to preclude inappropriate use until compliance with the applicable technical requirements is demonstrated. Vendor qualifications are reviewed as part of the bid process and are taken into consideration prior to bids being awarded. Vendor site visits may be conducted periodically throughout the duration of the fabrication contracts to ensure quality requirements are understood and being adhered to properly.

Within Fermilab facilities, a Traveler will accompany each component through the assembly process. These information packets are used to identify, report, correct, and trend non-conformance situations adverse to quality detector performance. The Travelers will contain whatever historical information accompanies the equipment, list the specified operating parameters, and provide a place for testing results to be entered. The test results and certifications will then be compared to the required specifications and a determination will be made as to the final use or disposition of the item. It should be noted that testing and verification for performance within proper operating parameters will occur multiple times throughout the construction process as was the case during past detector construction projects. This multi-tiered testing approach will ensure that improperly installed, faulty, or failed components are detected at the earliest possible opportunity and allow immediate remedial action to be taken without jeopardizing or negatively impacting detector operation.

14. INTEGRATED SAFETY MANAGEMENT

This section describes the policies for ensuring that Environmental, Safety and Health (ES&H) considerations are adequately addressed within the Run IIb CDF Detector Project activities. The information below provides an overview of key issues. Policies, procedures and descriptive information are contained in the CDF ES&H Implementation Plan. ES&H is a line management responsibility and will be implemented down through the sub-system organizations.

14.1 Overview

Fermilab subscribes to the philosophy of Integrated Safety Management (ISM) for all work conducted on the Fermilab site and requires its subcontractor and sub-tier contractors to do the same. Integrated Safety Management is a system for performing work safely and in an environmentally responsible manner. The term "integrated" is used to indicate that the ES&H management systems are normal and natural elements of doing work. The intent is to integrate the management of ES&H with the management of the other primary elements of work: quality, cost, and schedule. The seven principles of ISM are as follows:

(1) Line Management Responsibility for Safety: Line management is responsible and accountable for the protection of the employees, the public and the environment.

(2) Clear Roles and Responsibilities: The roles and responsibilities, and authority at all levels of the organization, including potential sub-tier contractors are clearly identified.

(3) Competence Commensurate with Responsibility: Personnel possess the experience, knowledge, skills and abilities that are necessary to discharge their responsibilities.

(4) Balanced Priorities: Resources are effectively allocated to address safety, programmatic and operational considerations. Protecting the public, the workers and the environment shall be a priority whenever activities are planned and performed.

(5) Identification of Safety Standards and Requirements: Before work is performed, the associated hazards are evaluated and an agreed upon set of safety standards and requirements are established which will provide adequate assurance that the public, the workers and the environment are protected from adverse consequences.

(6) Hazard Controls Tailored to Work Being Performed: Administrative and engineering controls, tailored to the work being performed, are present to prevent and mitigate hazards.

(7) Operations Authorization: The conditions and requirements to be satisfied for operations to be initiated and conducted are clearly established and understood by all.

The ES&H program at CDF is intended to ensure that all relevant and necessary actions are taken to provide a safe working environment at FNAL for the design, construction, installation, test, operation and decommissioning of the CDF detector. The CDF detector was designated a Low Hazard Radiological Facility and the Safety Envelope was approved in 1995. The Directorate, advised by the ES&H Section, will determine the need for updates or addenda to the

CDF Safety Assessment Document.

14.2 Objectives

The following general objectives have been established by FNAL for the ES&H program for detectors:

- Establish and administer an ES&H program that promotes the accomplishment of FNAL ES&H objectives for employees and non-employees.
- Protect the general public and the environment from harm.
- Comply with federal, state and local laws, rules and regulations.
- Prevent personnel injury or loss of life during detector-related work.
- Prevent damage to equipment caused by accidents during detector-related work.
- Prevent any environmental contamination during detector development, fabrication, commissioning and operation.

14.3 Organization and Responsibilities

The ES&H program for the entire Run IIb CDF Detector Project is the responsibility of the CDF Run IIb PM. The CDF PM and his designees are responsible for establishing policies and requirements for ES&H during development and commissioning of the detector, and related experimental systems.

The CDF PM has the responsibility for identifying specific ES&H issues and risks, and for ensuring that PL's establish appropriate safeguards and procedures for addressing those risks for each subproject. The PM is responsible for ensuring that CDF Safety documentation is adequate for operating the upgraded detector. The PM and the appointed Project Leaders are the laboratory line management on matters of environment, safety, and health for both the CDF Project and for operations aspects of the upgraded detector. The resources of the Particle Physics Division ES&H Department are also available to the Project Manager and Project Leaders upon request. Ad hoc review committees, reporting directly to the PPD Head, will be assigned as appropriate.

14.4 Documentation and Training

The CDF PM is responsible for providing, as required, specific requirements and procedures, as well as hazard assessments, and other documents to comply with DOE and FNAL requirements. CDF ES&H documents are defined in the CDF Operations Guidelines Manual.

Those who are on the CDF project at the FNAL site will be provided with the training and information necessary to reduce the risks associated with their work and to ensure their safety. Briefings and presentations will be made to all managers and supervisors to communicate ES&H policies, documentation and information associated with assuring safety of CDF activities. Job-specific training will be provided on issues including electrical safety, cryogenic safety, radiation safety and chemical safety, as well as issues related to detector transportation, installation and testing activities. Proficiency testing is performed to gauge comprehension.

All visitors to CDF will be informed of FNAL ES&H rules and procedures applicable to their visit. In general, visitors will not be allowed to work in areas without the advance permission of the CDF Project Manager or his/her designee. All visitors to CDF must be accompanied by a Host who is familiar with FNAL and CDF ES&H rules and procedures. Hosts are responsible for the safety of the visitors they accompany.

APPENDIX A: List of Referenced Documents

CDF Run IIb Detector Technical Design Report

CDF Run IIb Cost and Schedule Plan

CDF Memoranda of Understanding and Work plans for each sub-project

Justification of Mission Need

Fermilab Project Control Systems Guidelines, May 1, 1994.

Acquisition Execution Plan [for] Run IIb CDF Detector Project and Run IIb D-Zero Detector Project at Fermi National Accelerator Laboratory

DOE Project Execution Plan for Run IIb CDF Detector Project and D-Zero Detector Project at Fermi National Accelerator Laboratory

Fermilab Environment, Safety, & Health Manual

A Guide to the Project Management Body of Knowledge, ©2000 Project Management Institute

APPENDIX B: List of Schedule Milestones

The table below lists the Level 2 milestones from the resource loaded schedules. Level 0 and 1 milestones are contained in table 7.4 of the PEP.

WBS	Level	Title	Date
1.1.5.4.1.13	2	L2MS Prototype stave #1 complete	5-Dec-02
1.1.2.1.2.4	2	L2MS 2nd chip submission	20-Feb-03
1.1.2.10.2.4	2	L2MS Testing #1 complete- go ahead for #2	3-Apr-03
1.2.2.2.7.4	2	ASD->TDC Cables ready for installation	4-Apr-03
1.3.3.2.3.4	2	Fabrication of Prototype Finder 1/3 board	9-Apr-03
1.2.2.2.7.2	2	CEM Splitters ready for installation	11-Apr-03
1.2.1.10.1	2	First phototube order placed	9-May-03
1.2.2.2.7.1	2	Prototype Testing Complete	15-May-03
1.1.3.1.2.4	2	Production Sensor submission	16-May-03
1.3.3.8.1.9	2	Prototype Linker Module available for testing	9-Jun-03
1.2.2.2.7.3	2	PEM Harnesses ready for installation	2-Sep-03
1.2.2.2.7.5	2	All cables done and ready for installation	2-Sep-03
1.1.2.1.3.5	2	L2MS Production chip submission	9-Sep-03
1.3.5.2.5	2	arrival of 0/10 PCs from the vendor	10-Sep-03
1.2.1.10.2	2	1st WLS fiber holder finished	7-Oct-03
1.2.2.2.7.8	2	VME Crate ready for installation	7-Oct-03
1.1.2.10.3.4	2	L2MS Go ahead for Preproduction	11-Nov-03
1.3.1.6.7	2	First Prototype TDC available for testing	19-Nov-03
1.1.6.3.1.1.5	2	Milestone: all tests of stave installation, screen mounting, complete	5-Dec-03
1.2.1.10.4	2	1st CPR module finished and tested	11-Dec-03
1.2.2.2.7.10	2	Upstairs components ready for installation	7-Jan-04
1.2.2.2.7.11	2	All EMTiming components ready for installation	7-Jan-04
1.2.2.2.7.6	2	ASD/TB ready for installation	7-Jan-04
1.2.2.2.7.7	2	Downstairs components ready for installation	7-Jan-04
1.2.2.2.7.9	2	TDC boards ready for installation	7-Jan-04
1.2.1.10.3	2	First set of phototubes tested	30-Jan-04
1.2.1.10.6	2	1st CCR module finished and tested	12-Feb-04
1.1.2.3.1.3.12	2	L2MS preProduction hybrid available	25-Mar-04
1.2.1.10.5	2	Second set of phototubes tested	21-May-04

Milestone table continued:

WBS	Level	Title	Date
1.1.5.2.2.8	2	L2MS L0 prototype modules complete	26-May-04
1.3.4.4.1.4	2	arrival of the hardware	3-Jun-04
1.2.1.10.7	2	50% CPR Detectors Tested	4-Jun-04
1.3.3.10.3.3	2	Begin Preproduction Stereo Association Modules	21-Jun-04
1.3.4.5.3	2	Production Readiness Review - Event Builder	24-Jun-04
1.1.2.10.4.6	2	L2MS Goahead for DAQ production	19-Jul-04
1.2.1.10.8	2	50% CCR Detectors Tested	30-Aug-04
1.3.2.6.3	2	Begin production of Level2 Pulsar system	16-Sep-04
1.3.3.2.6.9	2	Begin Production Finder SL7 boards	12-Oct-04
1.1.2.3.1.4.9	2	L2MS Production hybrid available	9-Nov-04
1.3.3.8.3.3	2	Begin Production Linker Modules	13-Dec-04
1.3.6.5	2	SVT ready for installation	13-Dec-04
1.1.5.3.4.8	2	L2MS Production module available	5-Jan-05
1.3.1.12	2	Beginning of TDC Production	10-Jan-05
1.3.4.5.4.4	2	arrival of the hardware	3-Feb-05
1.2.1.10.10	2	Final CCR Detector Tested	24-Mar-05
1.2.1.10.9	2	Final CPR Detector Tested	24-Mar-05
1.3.5.5.5	2	arrival of 70 Level3 and 15 DAQ PCs from the vendor	24-Mar-05
1.3.5.6.5	2	arrival of 140/20 PCs from the vendor	24-Mar-05
1.3.5.8	2	Finish Purchase of Computers for Level3/DAQ system	14-Apr-05
1.1.6.1.11.3.5	2	L0 Supports Complete	5-May-05
1.3.4.8	2	Finish Event-Builder Upgrade	5-May-05
1.2.1.10.11	2	Final set of phototubes tested	6-May-05
1.2.1.10.12	2	End of Central Preshower Project	6-May-05
1.2.3.5	2	End of Calorimetry Project: Level 2	6-May-05
1.1.5.4.4.11	2	L2MS 100 Production staves complete	26-May-05
1.3.1.14.16	2	Data Concentrator Production Completed	2-Jun-05
1.3.2.9	2	Pulsar Level 2 subproject ready for installation	8-Jun-05
1.1.6.3.1.3.3	2	L2MS Stave Installation Begins	24-Jun-05
1.3.3.10.4.6	2	Production Stereo Association Modules complete	6-Jul-05
1.3.3.23	2	XFT Ready for Installation at CDF	6-Jul-05
1.3.1.13.10	2	Production Board testing complete	30-Sep-05
1.3.1.16	2	Run 2b TDC Ready for Installation	30-Sep-05
1.3.8	2	Finish Run 2b Trigger DAQ project	30-Sep-05
1.1.5.4.4.14	2	L2MS Production staves complete	18-Oct-05
1.1.6.3.1.3.8	2	L2MS Stave Installation Complete	8-Dec-05
1.1.6.3.2.3.6	2	L2MS Inner detector complete	4-Jan-06
1.1.6.3.1.3.16	2	Outer detector complete	23-Feb-06
1.1.6.4.8	2	L2MS SVX2b Ready for Installation into ISL	31-May-06

APPENDIX C: Quality Management Program

1. PROGRAM

1.1 Run IIb CDF Detector Project Mission

The mission of the Fermilab Run IIb CDF Detector Project is to support the Fermilab High Energy Physics (HEP) research program by constructing a new detector for use at CDF during Run IIb. The Directorate approves HEP experiments and allocates funds to provide the facilities, personnel, and equipment required to achieve successful completion of this mission. The Run IIb CDF Detector Project Office is responsible for ensuring the quality of the support mechanisms, all FNAL fabricated items, and non-FNAL supplied items that may have either an operational impact or an Environmental, Safety, and Health (ES&H) impact. This responsibility includes assuring proper integration of the new detector into the existing experiment infrastructure as well as establishing and enforcing Department of Energy (DOE) requirements. The Project Manager must ensure that the Project structure and organization are appropriate for effectively carrying out this mission.

1.2 Organization

The Run IIb CDF Detector Project is composed of the Project Management Office and four main working groups. These four working groups are organized according to the Work Breakdown Structure (WBS) assigned to the Project and are listed in the main body of the CDF Project Management Plan (PMP) and an organization chart is maintained by the Project Manager. General descriptions of the primary functions for the groups are also found in the Project Management Plan. Level 2 Managers set QA goals and objectives pertaining to their work environments and periodically assess progress toward them.

1.3 Roles, Responsibilities, and Authorities (RRA's) for Quality

RRA's for Quality flow down through the Project as outlined in the Fermilab Quality Assurance Policy, Section 10 of the *Director's Policy Manual.* The Project Manager assigns the QA/QC function to the appropriate manager for the Run IIb CDF Detector Project. Stop Work Authority related to quality of work has been delegated to all management and supervisory personnel within the Project. They are authorized and expected to halt unsatisfactory work being performed by any of the individuals or organizations reporting to them. The Division Head and Project Manager may specify other stop work authority outside of the normal management chain at their discretion.

2. PERSONNEL TRAINING AND QUALIFICATION

2.1 Scope

The Project supports Fermilab efforts with respect to personnel training and qualification, and believes that maintaining a trained and qualified work force is instrumental in ensuring the quality of products and services provided by the Project. This section describes the responsibilities and requirements necessary to provide the Project with qualified personnel who possess the appropriate level of skill, experience, and academic qualifications to support the achievement of the Project mission and performance objectives.

The Project Manager requires that all Project personnel be trained and have the appropriate experience to ensure that they are capable of performing their assigned work in a safe and efficient manner. This training must reflect the fact that the Project's scope of work involves the collaborative effort of personnel who have widely divergent levels of education, skills, and experience.

2.2 Education and Qualifications

Line management will ensure that assigned personnel have the appropriate level of qualifications. Qualifications may be job related experience or skills; technical and/or professional society certifications; formal education; or any combination thereof.

The education that is required for obtaining a university/college degree (or other professional certification) constitutes qualification for working within the discipline in which the degree was granted. Equivalent work experience and technical activity in a related discipline may also constitute acceptable qualifications.

2.3 Specific Job Related Training

When it is determined that an employee needs specific job related training in order to effectively and efficiently carry out duties that are assigned, training will be made available to the employee. In-house training will be provided to ensure that an appropriate level of skills, knowledge, expertise, and experience are available to accomplish stated mission and objectives. Training may come from several sources such as mentoring, or be provided by physicists, engineers, supervisors, lead personnel, consulting firms, QA personnel, ES&H personnel, and/or other sources.

In order to ensure that training skills are maintained at an appropriate level, an Individual Training Needs Assessment (ITNA) is required for each employee on an annual basis or whenever a change in job assignment and/or job hazards occurs. The annual training needs assessment shall be performed and reviewed with each employee in conjunction with the Fermilab Employee Performance Review process. This shall include a review of employee training needs with respect to the work the employee is expected to perform or hazards to which the employee would be exposed during the normal performance of the assigned job.

Managers are chosen for their technical and communication skills. The Project does not specify any further training or education for these personnel beyond what they initially bring to their positions. However, the Project Manager may also require further technical training for key personnel.

Supervisors within the support groups outside of the Project are chosen by their Department Heads. Supervisory positions include Deputy Department Heads and Group Leaders. These personnel are selected primarily for their technical abilities. If deemed useful by the Department Head, an individual supervisor may be required to attend the Supervisory Development course taught by Laboratory Services Section (LSS). The Department Head may also require additional training or education, oriented toward development of technical and/or supervisory skills, but there are no generally applicable requirements mandated by the Project.

3. QUALITY IMPROVEMENT

3.1 Scope

Achieving quality is a line responsibility. The Project encourages personnel to eliminate problems and improve performance. Managers are encouraged to use statistical methods or other management tools to help make the decisions necessary to improve quality for their operations. These methods may serve as a basis for trending, for continuous quality improvement from lessons learned, or to help foster a positive attitude toward quality initiatives. Managers are also encouraged to document non-conformances and identify, analyze, resolve, and follow up on recurring problems.

The Project has a strong commitment to continuous quality improvement in all areas and activities for which it is responsible. All levels of personnel are encouraged to report performance problems and maintain a "no fault" attitude toward individuals identifying concerns. Stop Work Authority related to quality of work is described above in Section 1.3, Roles, Responsibilities, and Authorities for QA. The objective is to identify a problem, to promptly report it to the appropriate level of management for corrective action, and for management to take the necessary corrective action commensurate with the programmatic significance or importance of the problem.

3.2 Identification/Reporting of Concerns and Non-conformances by Employees

A series of regular meetings have been established to allow employees to report and discuss performance problems. Project management has regularly scheduled weekly meetings to assess the progress of Project initiatives. Level 2 and 3 Managers present status reports at these meetings and free and open discussion of concerns is encouraged. Lessons learned are thus disseminated and are also utilized for additional feedback concerning quality improvements. Each Project group has its own methods for evaluating problems and performance. These include regular meetings and discussion by appropriate supervisory and technical personnel.

3.3 Documentation and Reporting

Quality non-conformances identified during operations, inspections, and design reviews shall be documented as appropriate. For problems with Fermilab-procured items and services, the Business Services Section (BSS) Procurement Department should be provided with details regarding non-conformances as specified below in Section 7.4, Verification of Acceptable Quality.

Quality non-conformances for products and services procured outside of the Fermilab system are to be reported to the Project Manager by the appropriate Level 2 Manager. Procured items that do not meet Project specifications must not be used. It is the responsibility of the organization that received the items to properly segregate the material and decide on its final disposition.

4. DOCUMENTS AND RECORDS

4.1 Document Control

The Project determines which records require document control as part of the Configuration Management Program. These records are controlled for reasons of personnel safety as well as for legal and/or historical purposes.

4.2 Records Retention and Disposition

Records produced within the Project must be retained. A disposition schedule must be created and maintained in accordance with Fermilab guidance. Examples are the Technical Design Report (TDRs), Project procedures, Basis of Estimate (BoE) documents, survey results, non-conformance reports, design drawings, QA Travellers, etc. Records that are not forwarded to Fermilab as part of component shipments are not subject to Fermilab requirements.

5. WORK PROCESSES

5.1 Work Process Control

The Project Manager requires that each Level 2 and 3 Manager develop means for analyzing work processes to determine if the work is sufficiently complex or hazardous to be performed to written procedures. The responsibility for determining which work processes require procedures rests with the Department Head or Group Leader responsible for the activity. Guidelines for performing these determinations can be found in the Particle Physics Division Operating Manual as part of PPD_OPER_004, Integrated Safety Management.

5.2 Maintaining an Effective and Efficient Work Force

The Project Manager requires that each Level 2 and 3 Manager strive to maintain an effective and efficient work force. The Project attempts to appropriately utilize personnel skills in the assignment of work responsibilities. Ensuring that the Project successfully meets its objectives is accomplished by assigning personnel to particular tasks who have the appropriate skills, experience, academic qualification, or professional certification to complete the work. The Project relies on line management to monitor activities to successful completion and to take necessary steps to incorporate added expertise and effort when indicated. More detailed information is provided in Section 2.0, Personnel Training and Qualification, above.

5.3 Measuring and Test Equipment (MTE) Calibration

The necessity for calibration and control is dependent upon the application and criticality of the equipment. The Project Manager requires that each Level 2 and 3 Manager analyze their work process measuring and test equipment to determine the appropriate calibration requirements and develop an effective program for the necessary calibration activities.

6. DESIGN

6.1 Scope

Equipment designed by Project personnel follows federal codes; the *Fermilab Environment, Safety and Health Manual*; Laboratory standards; and accepted industry standards. Relevant personnel are required to incorporate sound engineering and scientific principles and appropriate technical standards into designs to ensure that they will perform as intended.

6.2 Design Interface

In some cases, the Project relies on organizations outside of Fermilab to generate complete design packages. Examples include the EM Timing work and the Calorimeter upgrades. Each collaborating institution agrees to the scope of work they will undertake for the Project by means of a Memorandum of Understanding (MOU) and specific Statement of Work (SOW). These documents are generated and kept on file by the Project Office and reviewed at appropriate times in order to keep them current.

6.3 Project Reviews and Operational Clearances

Hazard assessments are performed by the Project at the initial design stages. The information from these hazard assessments is used to determine what reviews are necessary for the experimental apparatus. These are also used to develop the Operational Readiness Clearance (ORC) checklists for the Project. The Project must have an ORC completed, signed, and accepted prior to start-up.

The Project Manager may commission ad hoc technical review panels from within the Laboratory or the CDF Collaboration to review experimental apparatus when the need arises. The Project Manager also has the option to request assistance from the Laboratory Safety Committee for equipment reviews involving resources outside of the Project. Examples of this would be cryogenic systems, hydrogen targets, flammable gas systems, mechanical apparatus, etc.

7. PROCUREMENT

7.1 Scope

This section describes the Project's program to ensure that procurement practices are in accordance with established Fermilab policies. Collaborating universities are only bound to Fermilab's procurement requirements in cases where Fermilab actually participates in the procurement process.

7.2 Equipment and Services Procurement

The Run IIb CDF Detector Project procurement guidelines follow the *Fermilab Procurement Policy and Procedures Manual*. This manual, produced and maintained by the Business Services Section, includes instructions for the preparation of purchase requisitions and dictates responsibility for review and approval.

The Project Manager and the Budget Analyst have established levels of signature authority for purchase requisitions written against Project budget codes. The Project is responsible for transmitting this information to the Procurement Department and for monitoring proper conformance to the pre-determined signature levels. A review by various Project personnel may be required, depending on the dollar amount and/or type of purchase requisition or task order.

7.3 Budget Activity and Documentation

Budget activity and change control for the Project is handled in accordance with the approved Project Execution Plan (PEP) and Project Management Plan. The Financial Management System (FMS) in use by Fermilab allows individual cost codes to be established, where necessary. The Budget Analyst has the responsibility for establishing the proper cost codes. The FMS is also used to track and monitor such expenses as charge-backs from other Divisions/Sections, and other Fermilab related costs. At the successful completion of each project phase or WBS task, the Project Manager or designated representative is required to verify that work was performed and completed in accordance with acceptable standards before final payment is authorized by the Business Services Section.

7.4 Verification of Acceptable Quality

At all levels of the Project, QA of purchased material is the responsibility of the requisitioner. Parts and equipment ordered for use must include exact specifications where necessary. This may be achieved by including exact specifications on the purchase requisition and/or by using a Sole Source document. If the materials received do not meet the specifications detailed in the original requisition, then the requisitioner must notify Purchasing to resolve any discrepancies. If unacceptable parts are discovered through the normal course of use, Purchasing must be informed of the problem. Purchasing will notify the vendor involved and bring the situation to final resolution. Departments are encouraged to document QA non-conformances that may have a negative impact on system performance.

8.0 INSPECTION AND ACCEPTANCE TESTING

8.1 Requirements

Contracted work, purchased equipment, or items produced in Fermilab shops requiring formal inspection and acceptance testing must be identified. When an inspection or acceptance test is to be performed, the inspection techniques to be used will be defined by the testing group. Testing requirements and techniques may be referenced in the resource loaded schedule, a procurement contract, a Memorandum of Understanding, or a Hazard Assessment document. Level 2 Managers are required to identify essential safety items or systems that require formal inspection and testing.

8.2 Documentation

Managers must ensure that the documentation for items that require inspection and acceptance testing is maintained in accordance with the appropriate DOE records retention schedules.

9.0 ASSESSMENT

9.1 Project Management Assessments

The Project Manager has the authority to form an ad hoc review team to investigate quality assurance or quality control non-conformances if the need arises. These formal reviews would be conducted and documented in the Fermilab ES&H Database and Tracking System (ESHTRK).

9.2 Independent Assessments

The QA Program is part of the overall project implementation and is assessed as part of the planned reviews conducted by the Directorate and selected DOE representatives. It is the responsibility of the Project Manager to ensure the information necessary for the review is available and that knowledgeable personnel are available to present the material to the review committees. The Project Manager would also be charged with responding to findings from the independent assessments in accordance with schedules established by the reviewing body and taking action to correct any deficiencies identified by the independent assessments.

APPENDIX D: Configuration Control Program

1. PURPOSE

This Configuration Management Program (CMP) describes the configuration management (CM) responsibilities and processes that support the design and implementation of the Run IIb CDF Detector. The purpose of this CMP is to identify the organization providing the configuration control, define what a configuration-controlled item is, describe the change control process, and identify the plan for configuration status accounting and verification. This CMP is designed to ensure that:

a. Baselines are defined and documented,
b. Documentation is identified, released and controlled,
c. A Configuration Control Board (CCB) is established and functions according to CMP guidelines,
d. Changes to the baseline are evaluated and controlled,
e. Approved configuration changes are implemented and tracked, and
f. Configuration status accounting is accomplished.

Systems and components specific to the Run IIb CDF Detector Project have been reviewed in accordance with the principles provided in ANSI/EIA-649-1998, *National Consensus Standard for Configuration Management*. "Configuration management practices should be applied selectively, and to a degree commensurate with the application environment."[1] We have tailored the degree of rigor employed based on the functions and importance of each system or component. Table D.1 provides a summary of the principles and a brief description of how each principle was addressed by the Project.

2. PROGRAM OVERVIEW

A CMP is employed by the CDF Project to identify and control Run IIb relationships with respect to design and construction of the Run IIb CDF Detector. The Project recognizes the importance of maintaining clear, concise, and accurate records in order to stay on schedule, remain within cost constraints, and provide complete information for future operation, maintenance, and decommissioning activities. This Program has been established to ensure that key functional organizations, both internal and external to Fermilab, are aware of their roles and responsibilities during the design, construction, and testing phases of the Project. Detector design requirements and documents have been fully established and will be maintained in a way that they will be complete and accurate throughout the lifetime of the detector.

The main goal of the CDF Project CM Program is to prevent unauthorized or uncontrolled physical hardware changes to equipment, changes to controlled documents, and changes to controlled software. The program integrates the various CM control systems already in place

[1] ANSI/EIA-649-1998, *National Consensus Standard for Configuration Management*. Page 1

and augments where needed. It is also meant to focus on the control of active documents and not on longer-term records management, retention, or archiving. Records management issues will be addressed according to the requirements listed in DOE Order 200.1, Information Management Program.

The key elements of CM are Configuration Identification, Configuration Change Control, Configuration Status Accounting, and Configuration Verification. Configuration Identification defines the system through drawings and documents that specify the system components in terms of functional and physical characteristics, as well as how they will be manufactured and tested. For convenience, the system is broken down into Configuration Items (CIs). The CIs are listed in a Configuration Items Data List (CIDL), which is a database that lists each CI and its defining documentation. The CIDL is also used to track proposed changes to CIs. The Change Control process is the vehicle by which proposed changes are reviewed and approved. It ensures that the technical, cost and schedule impacts of each major change are considered before approval is granted. Configuration Status Accounting is a means to track configuration information and relay it to key personnel in order to support management decisions and ensure that all work is performed according to the current design. The Configuration Verification process ensures that the current hardware and software configurations match the intended design by verifying the implementation of each approved change and through periodic configuration audits.

3. SCOPE AND APPLICABILITY

3.1 Scope

This CMP is applicable to all work performed as part of the Run IIb CDF Detector Project, which includes the design, testing, integration, and assembly of components. It provides guidance for all personnel on CM activities in support of the Project, including all subsystem teams, collaborations, and subcontractors. CM is applied to items selected by the Project Manager and includes hardware and software components along with the related design documents, specifications, drawings, procedures and other support documents. The scope of this CMP encompasses the lifecycle of the Project.

3.2 Applicability

In general, the following classes of documents are included in the Configuration Management Program:

- Mechanical and electrical design drawings showing the specifications for the equipment and subcomponents
- Technical Design Report
- Management documents such as the Baseline Schedule, PMP, MOU’s, and SOW’s.

4. ACRONYMS AND DEFINITIONS

4.1 Acronyms

CCB – Configuration Control Board
CI – Configuration Item
CIDL – Configuration Items Data List
CM – Configuration Management
CMP – Configuration Management Program
CR – Change Request
DCN – Document Change Notice
ICD – Interface Control Document
L2 Manager – Person responsible for activities at Level 2 of the Work Breakdown Structure
L3 Manager - Person responsible for activities at Level 3 of the Work Breakdown Structure
PAC – Physics Advisory Committee
PEP – Project Execution Plan
PM – Project Manager
PMG – Project Management Group
PMP – Project Management Plan
SiDet – Silicon Detector Facility at Fermilab
TDR – Technical Design Report

4.2 Definitions

Baseline – An arbitrary point at which a project design or requirements are considered to be "frozen" and after which all changes must be tracked and approved.

Change Classification - All proposed changes to Project documentation submitted to the CCB for consideration are designated as Class I, II, or III changes. Configuration changes may affect hardware, software, verification requirements and the documents, drawings and procedures which define them.

Class I Change – A proposed change that impacts the form, fit, or function of the Detector. Class I changes are Out-of-Scope changes that would alter the physics capabilities of the detector in a major way or introduce a new detector system. This is described further in Section 10.5.1 of the CDF PMP.

Class II Change – A change that does not alter the Scope of the Project as defined in Section 10.5.1 of the CDF PMP. These are In-Scope changes and are described in Section 10.5.2 of the CDF PMP.

Class III Change – A proposed change that is not classified as Class I or II. This includes changes that affect the design of a subsystem but do not change the ability of that subsystem to meet its functional and design requirements. Changes to correct clerical errors or to add clarification to documents are also classified as Class III. Class III changes are authorized by the manager of the originating organization.

Configuration Control Board (CCB) – A board composed of technical and administrative representatives who recommend approval or disapproval of proposed changes to a CI's current approved configuration documentation. This is currently considered to be the CDF PMG.

Configuration Item (CI) – An aggregation of hardware or software that satisfies an end use function and is designate for separate CM.

Configuration Items Data List (CIDL) – A CDF Project-controlled database that identifies all CIs and contains tracking and status information for changes to the CIs.

Configuration Management (CM) – The systematic control and evaluation of all changes to documentation that has reached a baseline point.

Pending Changes - Pending changes are those for which conceptual design has been approved, changes that have been approved for implementation, or approved unincorporated changes that have been implemented in the field but for which the document revision has not been completed.

Technical Design Report – Defines the technical specifications, physical characteristics, and functional operating parameters of the Run IIb CDF Detector.

5. RESPONSIBILITIES

5.1 Project Manager

Project Manager is responsible to:

- Oversee and coordinate project configuration control activities,
- Approve all changes to the project cost and schedule baselines,
- Notify the Project Management Group of any need to change a document or system as soon as that need is identified and determined to be valid.
- Ensure that all project CIs are identified and controlled.
- Ensure any changes to controlled documents are appropriately recorded, tracked, and incorporated into existing drawings or documents in a timely manner,
- Ensure any additional testing or certification required as a result of changes are explicitly called out and included in the appropriate places,
- Maintain a database that identifies controlled documents and owners of those documents for the Project,
- Periodically audit the CM Program to determine the effectiveness of the Program. This may include reviewing controlled copies of documents to ensure their accuracy and their consistency with the master copies.

5.2 Level 2 Managers

Level 2 Managers are responsible to:

- Maintain CM control over their areas of responsibility and subcontractors,
- Notify the PM of any need to change a document or system as soon as that need is identified and determined to be valid.
- Ensure the PM is informed of as-built changes and revisions to controlled documents,
- Assess impacts of proposed changes on cost, schedule, resources, risk, technical performance, and scientific objectives,
- Implement approved changes to the project cost and schedule baselines.

5.3 Level 3 Managers

Level 3 Managers are responsible to:

- Keep track of progress on work activities under their control, including work by subcontractors and collaborations,
- Notify the Level 2 Manager of any need to change a document or system as soon as that need is identified and determined to be valid.
- Ensure that people under their authority use the latest versions of documents available,
- Transmit changes made as a result of field work up the chain of command in an orderly and timely manner.

5.4 Document Control Managers

Document Control Managers are responsible to:

- Ensure that only the latest versions of documents are disseminated and available for use and outdated documents are replaced throughout the system. If outdated documents are requested for any reason, they shall be labeled as outdated or obsolete in a clear and distinctive manner.

6. CONFIGURATION MANAGEMENT PROCESS

The CM process consists of four ongoing stages: (1) configuration identification, (2) change control, (3) configuration status accounting, and (4) configuration verification.

6.1 Configuration Identification

Configuration identification is the ongoing process of identifying and documenting the detector's functional and physical characteristics, from initial requirements selection through design, development, fabrication, test, and delivery. Configuration identification provides unique identity to detector components as well as the configuration documentation.

6.1.1 Baseline Definition

The configuration identification is developed and maintained via the peer review process and a series of formal technical and management reviews. The peer review process includes the Physics Advisory Committee, the CDF Collaboration, and the Project Management Group. Formal reviews are conducted by the Fermilab Directorate, the Department of Energy, and outside consulting groups in the employ of the DOE.

6.1.2 Configuration Items

In order to facilitate CM, the detector systems and components will be broken down into manageable units, called Configuration Items (CIs). CIs are identified through a top-down analysis that divides the total system into logically related and subordinate aggregates of hardware and/or software. The main criteria is to select those items whose performance parameters and physical characteristics can be separately defined, tested, and managed.

6.1.3 Configuration Items Data List

All CIs will be listed in a Configuration Items Data List (CIDL). The CIDL is a database containing relevant information about each CI, such as item number, title, revision history, responsible organization and manager, release date, etc. The CIDL will also identify the documents that define the CI. These documents are controlled through CM and may include, but are not limited to, specifications, drawings, interface control documents (ICDs), software description documents, databases, and procedures. Where the design incorporates commercial off-the-shelf (COTS) hardware or software, the vendor part number will be used in drawings and specifications. The design data and documentation owned by the vendor is not subject to, and therefore not included in, the CDF Project CMP.

6.2 Change Control

Change control is the process by which the CDF Project Office manages and approves the release and update of configuration-controlled items. This process aims primarily at ensuring that only currently approved revisions of documents are in use. Tracking features support this aim through the maintenance of information on the current status of documents and the provision of information on pending changes. The major features for effective control are discussed below

6.2.1 Initial Release

Drawings and documents are placed under configuration control upon their initial release. Prior to initial release, the originator should submit the item to peer or expert review, as applicable. Initial release is accomplished by submitting a completed and approved Document Change Notice (DCN) to the Project Manager via the appropriate L2 or L3 Manager. The item is then entered into the CIDL. Secure master files of the original documents are maintained in the appropriate place. If the document is created by an off-site facility, the off-site entity may retain control of the master file with the express authorization of the CDF Project Manager.

6.2.2 Change Control Process

Updates to released documents are accomplished through the change control process. This process is used to classify proposed changes and manage the approval process accordingly. All proposed changes are assigned a classification of Class I, Class II or Class III based on the level of impact to the overall system. Refer to Sections 8 and 10 of the CDF PMP for more detailed information about the specifics of the change control process.

The change control process is started when a need for change is identified and the responsible person submits a Document Change Notice (DCN) to the appropriate manager for approval. Class III changes are managed and controlled at the subsystem level. The DCN is used to inform the rest of the team of approved changes and to cause the CIDL to be updated. If the proposed change requires PMG approval, then the DCN and an accompanying Change Request (CR) are forwarded. Prior to the PMG meeting, the PM conducts an informal screening to make sure the CR is complete and accurate. The PM may request additional support documentation, reports and/or analyses for the PMG presentation. The PMG then evaluates the CR and recommends that it be approved or rejected. Class I changes are then sent to DOE for approval as per Section 8 of the CDF PMP. When the appropriate level of approval has been granted, the DCN and CR forms are routed and distributed to the Project team. The approved CR directs the Project team to implement the change.

A formal, internal technical review panel will be convened by the Project Manager if dramatic technical changes become necessary during the course of the Project. This review will address questions relating to the need for the proposed change, the benefits versus the cost and schedule impacts, and the availability of adequate resources to successfully complete the change.

6.2.3 Document Change Notice

A Document Change Notice form (Figure 10.3 in the CDF PMP) is used to notify the Project team that an approved change has been implemented. The DCN may announce the release of a new revision or may be attached as an amendment to the current revision.

6.2.4 Change Request Form

The Change Request form (Figure 10.2 in the CDF PMP) accompanies the DCN when submitting a proposed change. The CR provides the information about the technical performance, cost and schedule impacts of the proposed change.

6.2.5 PMG Operations

The PMG is primarily responsible for reviewing all Class I and Class II CRs for merit based on the impact to cost, schedule and technical performance. The PMG may also be called on to evaluate and approve or reject Collaboration change requests and subcontractor requests for deviation or waiver.

6.3 Configuration Status Accounting

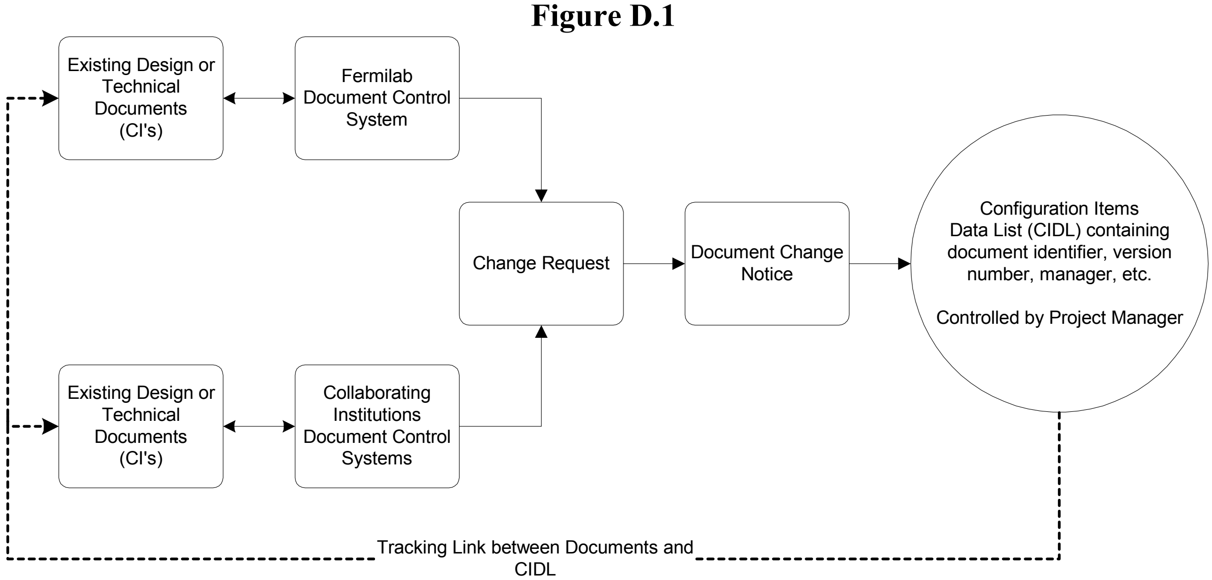
The CIDL provides the ability to track all changes to CIs. The database will contain information providing traceability and status of all change requests. The CIDL will maintain the change history of all CIs so that the evolution of the system will be documented. The CIDL serves as the vehicle for communicating the status of configuration through periodic reports and direct real-time inquiries.

6.4 Configuration Verification

The Subsystem Managers are responsible for implementing and closing the PMG-approved changes to CIs that are under their control. The DCN serves as notice that a document change has been implemented and verified. The verification of hardware changes is reported by signing the bottom of the CR form and returning it to the PM. In this manner, all changes can be tracked to completion and easily audited. All CIs will be audited prior to delivery for integration into the higher-level system to ensure that the as-built configuration conforms to the configuration documentation.

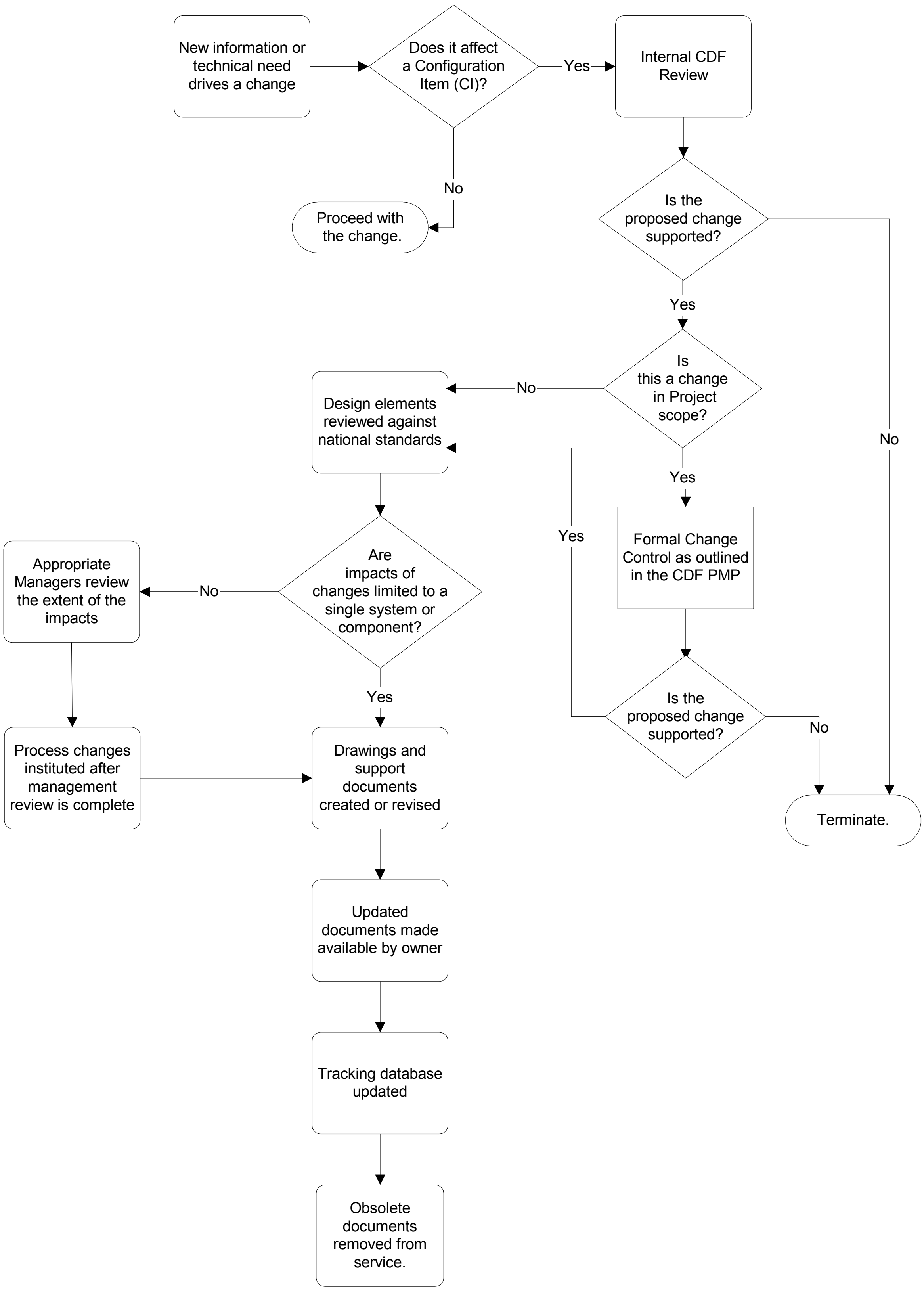
CDF Run IIb Document Identification and Control

Figure D.1



CDF Run IIb Configuration Management Flowchart

Figure D.2



ANSI/EIA-649-1998 Summary of Configuration Management Principles

Table D.1

No.	Principle	How it is Addressed
1	Plan CM processes for the context and environment in which they are to be performed and manage in accordance with the planning: assign responsibilities; train personnel; measure performance; and assess measurements/trends to effect process improvements.	In the CMP – appendix D of the CDF PMP
2	To determine the specific CM value adding functions and levels of emphasis for a particular product, identify the context and environment in which CM is to be implemented	In the CMP – appendix D of the CDF PMP
3	A configuration management plan describes how configuration management is accomplished and how consistency between the product definition, the product's configuration, and the configuration management records is achieved and maintained throughout the applicable phases of the product's life cycle.	In the CMP – appendix D of the CDF PMP
4	Prepare procedures to define how each configuration management process will be accomplished	Figure D.2 (Flowchart)
5	Conduct training so that all responsible individuals understand their roles and responsibilities and the procedures for implementing configuration management processes.	Weekly meetings
6	Assess the effectiveness of CM plan implementation and performance of the configuration management discipline with defined metrics (performance indicators).	PM Responsibilities
7	Performing configuration management includes responsibility for the configuration management performance of subordinate activities (e.g., subcontractors, suppliers).	L2 and L3 Manager responsibilities
8	Configuration identification is the basis from which the configuration of products are defined and verified; products and documents are labeled; changes are managed; and accountability is maintained.	PMP Change Control, Sections 8 & 10
9	Configuration documentation defines the functional, performance, and physical attributes of a product. Other product information is derived from configuration documentation.	Described in *The CDF IIb Detector Technical Design Report* (TDR)
10	The product composition (i.e. relationship and quantity of parts that comprise the product) is determinable from its configuration documentation.	Described in the TDR
11	All products are assigned unique identifiers so that one product can be distinguished from other products; one configuration of a product can be distinguished from another; the source of a product can be determined; and the correct product information can be retrieved	Serial #'s and test data
12	Individual units of a product are assigned a unique product unit identifier when there is a need to distinguish one unit of the product from another unit of the product.	Serial #'s
13	When a product is modified, it retains its original product unit identifier even though its part identifying number is altered to reflect a new configuration	Not Applicable
14	A series of like units of a product is assigned a unique product group identifier when it is unnecessary or impracticable to identify individual units but nonetheless necessary to correlate units to a process, date, event, or test.	Not Applicable

15	All documents reflecting product performance, functional, or physical requirements and other product information are uniquely identified so that they can be correctly associated with the applicable configuration of the product	Described in the TDR
16	A baseline identifies an agreed-to description of the attributes of a product at a point in time and provides a known configuration to which changes are addressed	Described in the TDR
17	Baselines are established by agreeing to the stated definition of a product's attributes	Described in the TDR
18	The configuration of any product or any document, plus the approved changes to be incorporated is the current baseline.	Described in the TDR
19	Maintaining product information is important because time consuming and expensive recovery may be necessary if records of operational units of a product do not match the actual units (as reported by maintenance activities) or such records do not exist.	Serial #'s
20	For product interfaces external to the enterprise, establish an interface agreement and a mutually agreed to documentation of common attributes	MOU's and SOW's
21	Changes to a product are accomplished using a systematic, measurable change process	PMP Change Control, Sections 8 & 10
22	Each change is uniquely identified	Change Request and DCN
23	Changes represent opportunities for improvement	Change Request and DCN
24	Classify requested changes to aid in determining the appropriate levels of review and approval.	PMP Change Control, Sections 8 & 10
25	Change requests must be clearly documented	PMP Change Control, Sections 8 & 10
26	Consider the technical, support, schedule, and cost impacts of a requested change before making a judgment as to whether the change should be approved for implementation and incorporation in the product and its documentation	PMP Change Control, Sections 8 & 10
27	Determine all potential effects of a change and coordinate potential impacts with the impacted areas of responsibility	See Figure D.2 (flowchart)
28	Change documentation delineates which unit(s) of the product are to be changed. Change effectivity includes both production break-in and retrofit/recall, as applicable	Not Applicable
29	A changed product should not be distributed until support and service areas are able to support it.	Not Applicable
30	Decision-maker is aware of all cost factors in making the decision.	PMP Change Control, Sections 8 & 10
31	Change approval decisions are made by an appropriate authority who can commit resources to implement the change	PMP Change Control, Sections 8 & 10
32	Implement an approved change in accordance with documented direction approved by the appropriate level of authority	PMP Change Control, Sections 8 & 10
33	Verify implementation of a change to ensure consistency between the product, its documentation and its support elements	See Figure D.2 (flowchart)
34	If it is considered necessary to temporarily depart from specified baseline requirements, a variance is documented and authorized by the appropriate level of authority	PMP Change Control, Sections 8 & 10
35	An accurate, timely information base concerning a product and its associated product information is important throughout the product life cycle.	Figures D.1 & D.2
36	Configuration information, appropriate to the product, is systematically recorded,	Outlined in CMP

	safeguarded, validated, and disseminated	
37	Configuration information content evolves and is captured over the product life cycle as tasks occur.	Outlined in CMP
38	Data collection and information processing system requirements are determined by the need for configuration information	Outlined in CMP
39	Verification that a product's requirement attributes have been met and the product design meeting those attributes has been accurately documented is required to baseline the product configuration	Quality Management & Reviews
40	Verification that a design achieves its goals is accomplished by a systematic comparison of requirements with the results of tests, analyses, or inspections	Quality Management & Reviews
41	Documentation of a product's definition must be complete and accurate enough to permit reproduction of the product without further design effort.	Quality Management & Reviews
42	Where necessary, verification is accomplished by configuration audit	Outlined in CMP
43	Periodic reviews verify continued achievement of requirements, identify and document changes in performance, and ensure consistency with documentation	Quality Management
44	Apply configuration management principles to ensure the integrity of digital representations of product information and other data	Document Version Control
45	Apply digital data identification rules to maintain document, document representation, and file version relationships	Document Version Control
46	Apply business rules using data status levels for access, change management, and archiving of digital data documents	Not Applicable
47	Maintain relationships between digital data, data requirements, and the related product configuration to ensure accurate data access.	Document Version Control
48	Apply disciplined version control to manage document review electronically.	Document Version Control
49	Ensure that a transmitted digital data product is usable.	Quality Management
50	Effective digital data access fulfills requirements, preserves rights, and provides users with data they are entitled to in the correct version.	Not Applicable